DOCUMENT RESUME

ED 465 454 PS 030 436

AUTHOR	Hatcher, Juliet L.; Scarpa, Juliet
TITLE	Background for Community-Level Work on Physical Health and Safety in Adolescence: Reviewing the Literature on Contributing Factors.
INSTITUTION	Child Trends, Inc., Washington, DC.
SPONS AGENCY	John S. and James L. Knight Foundation, Miami, FL.
PUB DATE	2001-12-00
NOTE	96p.
AVAILABLE FROM	Child Trends, Inc., 4301 Connecticut Avenue, NW, Suite 100, Washington, DC 20008. Tel: 202-362-5580; Fax: 202-362-5533. For full text: http://www.childtrends.org/PDF/KnightReports/KHealth.pdf.
PUB TYPE	Information Analyses (070)
EDRS PRICE	EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Accidents; *Adolescent Development; *Adolescents; *Child Health; *Child Safety; Dental Health; Drinking; Driver Education; *Health Promotion; Injuries; Life Style; Literature Reviews; Nutrition; Physical Activity Level; *Prevention; Restraints (Vehicle Safety); Risk Management; Secondary Education; Sleep; Smoking
IDENTIFIERS	Bicycle Helmets; Risk Reduction; Risk Taking Behavior

ABSTRACT

Although adolescence is characterized by general good health, this developmental stage is a key time for promoting a healthy lifestyle and preventing health-compromising behaviors and injuries. This paper presents a selective review of research into factors predicting health and safety behavior patterns and injury occurrence, focusing on individual factors as well as factors at the family, peer, community, societal, and policy levels. Emphasized are studies that incorporate rigorous experimental evaluations of interventions, longitudinal studies identifying predictors of health and safety outcomes using multivariate analyses, and studies that have been replicated with similar results across different populations and geographic regions, with limited consideration of case-control investigations. The paper restricts discussion to studies measuring outcomes during adolescence. The health promotion behaviors considered are tobacco use, physical activity and nutrition, sleep, and dental health. The paper notes that more is known about why healthy behaviors are important than about what predicts these behaviors or what can be done to promote them. It is also noted that adolescents in lower income families bear a disproportionate share of unhealthy behaviors. The paper examines injury prevention, considering unintentional injuries as a group, motor vehicle injuries, bicycle injuries, and occupational injuries. Injury prevention programs described include driver education and programs to prevent drinking and driving and to promote seat belt use. The paper concludes by emphasizing the need for more high quality research to guide and inform health behavior promotion and injury prevention during adolescence. A table summarizes the research literature and implications for targeted activities to promote a healthy and safe lifestyle and to prevent injury among adolescents. (Contains 229 references.) (KB)

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Child TRENDS

Background for Community-Level Work on Physical Health and Safety in Adolescence: Reviewing the Literature on Contributing Factors

By
Juliet L. Hatcher and Juliet Scarpa

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December 2001

Prepared for the John S. and James L. Knight Foundation

PS 030436

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Acknowledgements

We thank our external reviewers—Jo Anne Grunbaum of the Division of Adolescent and School Health, Centers for Disease Control and Prevention; Arthur Peterson, Jr., of the Cancer Prevention Research Program, Division of Public Health Sciences, Fred Hutchinson Cancer Research Center and the Department of Biostatistics, University of Washington; and David Sleet of the National Center for Injury Prevention and Control, Centers for Disease Prevention and Control—for their thoughtful review and comments. We also thank Jonathan Zaff, the project manager, for his continuing support and insightful suggestions, which contributed greatly to the quality of this report; and Kristin Moore, for her helpful comments on an earlier draft. Finally, we would like to convey our great appreciation for the support of the Knight Foundation in funding this project, and, in particular, to John Bare for his integral role in shaping and guiding this series of reviews.

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Introduction

Most adolescents are relatively healthy. Nationally, in 1998, adults reported that only 2% of adolescents in their families were in fair or poor health.[1] Despite this general good health, there are many important opportunities to promote health during adolescence. Perhaps the most pressing physical health concerns during this developmental stage are the high prevalence of health-compromising behaviors, which affect health status during adolescence and beyond, and injuries—far and away the leading cause of death in this age group.

Methodology[2]

There is an extensive body of research on the factors that predict health and safety behavior patterns and injury occurrence, focusing on factors within the adolescent as well as within the various components of the environment (e.g., family, friends, schools and the neighborhood). In this paper, we present a selective review of the research pertaining to each layer of the adolescent's ecosystem. We emphasize (1) studies that are rigorously implemented, experimental evaluations of interventions, in which aspects of the environment are manipulated and health and safety outcomes are examined; and (2) studies that are longitudinal, involving the examination of aspects of the environment as predictors of health and safety outcomes, using multivariate analyses to take background characteristics into account.

We have emphasized these types of studies for several reasons. Experimental-control group studies are better at controlling for selection bias than other designs (as long as they are carefully implemented and there is not extensive attrition in the sample over time) and they also can address causal relationships more clearly than other designs. Randomized experimental-control studies have an added advantage of equalizing, on average, the distribution of background characteristics across the experimental and control groups, making these groups more equivalent and allowing for a more confident attribution of any group differences to the experimental manipulation itself. In addition, longitudinal studies that contain adequate consideration of background characteristics can address change over time and predictive validity better than cross-sectional studies.

We also highlight studies that have been replicated with similar results across different populations and geographic regions. Successfully replicated interventions appear to have a better chance of being replicated in additional locations than do studies that have been carried out only in a single place, at one single point in time.

For some issues, where linkages to health and safety outcomes have been well established (such as drinking as a risk factor for motor vehicle accidents, and bicycle helmets as a protective factor for head injury), we rely on studies that report basic descriptive findings or use a case-control design. A case-control design compares the exposure history of individuals who have had an outcome (cases) with the exposure history of comparable individuals who have not had that outcome. For example, a case-control investigation of the efficacy of bicycle helmets might compare the helmet use of individuals who had sustained a head injury in a bike accident (cases) with that of individuals who had been in a bike accident but hadn't sustained a head injury. An analysis would evaluate whether those with a head injury were less likely to have been wearing a helmet at the time of the accident, controlling for other important factors that may differ between the two groups. If those who had sustained a head injury were less likely to be wearing a helmet, the analysis would suggest that helmets protect against head injury in the event of a bicycle accident. The greatest challenge to the quality of case-control studies is the selection of an appropriate comparison group.

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[1] Author's analysis of data, on adolescents ages 12-17, from the 1998 National Health Interview Survey.

[2] These criteria for study inclusion in the present report were culled from a review of school readiness written for the John L. and James S. Knight Foundation (Halle, Zaff, Calkins, & Margie, 2000).

Since the focus of this paper is on adolescents, we have further restricted studies to those that measure outcomes during adolescence. Therefore, studies that have outcome data only among younger children or adults are not considered. However, we do include longitudinal studies that begin in childhood and continue into adolescence. Also, when little or no information exists for a certain topic, we have included very strong research for either children or adults that is suggestive of effects on adolescents.

Throughout this paper, our aim is to go beyond the broad identification of which factors appear to be linked to health and safety outcomes, to the identification of specific strategies (the kinds of programs and activities within these programs) that have been attempted and evaluated, and/or for which there is evidence that initiating programs with these activities has the potential to contribute to improved health and safety outcomes. Due to the criteria we set for our selected literature review, we may not have identified all programs and activities across the country that may be effective in promoting positive health and safety behaviors or preventing injury.

Promoting a Healthy Lifestyle

Many of the most common causes of morbidity and mortality in the United States are influenced by health behaviors, such as tobacco use, physical activity, and diet (Kann et al., 2000). These behaviors appear to track from adolescence into adulthood (Kelder, Perry, Klepp, & Lytle,1994), suggesting that promotion of good health behaviors in adolescence may have positive effects on future health behaviors and disease risks. The importance of establishing healthy habits in adolescence is reflected in the national Healthy People 2010 objectives to reduce tobacco use and to promote physical activity, a healthy diet, and good oral health among adolescents (U.S. Department of Health and Human Services [DHHS], 2000a). These vital health behaviors can be considered modifiable health *outcomes* in adolescence that are in turn antecedents of health status and healthy development over the lifespan. In this section, the antecedents of and program strategies for several health behaviors, including tobacco use, physical activity, nutrition, sleep, and dental hygiene, are explored.

Tobacco Use

Importance

Tobacco use is the leading preventable cause of death in the United States (Centers for Disease Control and Prevention [CDC], 1989; McGinnis & Foege, 1993). The CDC (1996b) has estimated that, if current patterns of tobacco use continue, smoking-related illnesses in this country will lead to the premature deaths of approximately 5 million persons among those who were minors in 1995. Tobacco use in various forms has been associated with such serious illnesses as cardiovascular disease, cerebrovascular disease, chronic obstructive pulmonary disease, and cancer—including cancers of the lung, larynx, mouth, esophagus, and bladder (Baker et al., 2000; CDC, 1994a; DHHS, 1994).

Tobacco use behaviors in adolescence are critically important to these increased risks. Individuals who smoke during adolescence are much more likely to be regular smokers in adulthood than are individuals who do not smoke during adolescence (e.g., Brook, Whiteman, Czeisler, & Shapiro, 1997; Chassin, Presson, Sherman, & Edwards, 1990; Kelder et al., 1994). Chassin and colleagues (1990) estimated—based on results from a predominantly white,[3] middle-class sample—that even trying a few cigarettes as an adolescent is associated with a more than doubled risk of smoking at least weekly in adulthood. Moreover, this study suggests that monthly or more frequent smoking during adolescence is associated with a 16-fold increase in the risk of weekly or more frequent smoking as an adult. Not only do many adolescent smokers go on to become adult smokers, but most adult smokers—about 4 of every 5—begin their smoking habit in adolescence (DHHS, 1994).

Also noteworthy are the more proximal consequences of exposure to tobacco during adolescence, including increased risk and severity of respiratory illnesses and limitation of lung growth and function (CDC, 1994a; DHHS, 1994).

Because of the extent and severity of health risks associated with tobacco use, researchers have produced a vast body of literature on this behavior. Despite this extensive study—and despite the well-documented and widely advertised health risks associated with tobacco—tobacco use remains common among adolescents today.

Prevalence and Trends

The CDC's Youth Risk Behavior Survey (YRBS) is a nationally representative survey of risk behaviors among high school students, and provides relevant data on tobacco use. According to the YRBS, in 1999, 70.4% of 9th to 12th graders nationwide reported trying cigarette smoking—even just one or two puffs—at some point in their lifetime so far (Kann et al., 2000). More than one-third of high-school students reported smoking cigarettes on one or more of the 30 days preceding the survey, and 16.8% reported smoking cigarettes on at least 20 of the preceding 30 days. One-quarter reported having smoked a whole cigarette before age 13. Other forms of tobacco use are also common. The YRBS results show that 14.2% of high-school boys—compared with only 1.3% of high-school girls—had used smokeless tobacco, such as chewing tobacco, snuff, or dip, on one or more of the 30 days preceding the survey. About one-quarter of high-school boys and one-tenth of high-school girls had smoked cigars (Kann et al., 2000). Other nationally representative surveys have produced similar prevalence estimates of cigarette and smokeless tobacco use (Johnston, O'Malley, & Bachman, 2000; Resnick, et al., 1997). Because each of these national surveys is school-based, these prevalence estimates are not representative of the drop-out population, among whom tobacco use tends to be more common (e.g., Chassin, et al. 1990). As a result, these estimates are likely underestimates of the true prevalence of tobacco use among adolescents.

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[3] Throughout this chapter, the terminology used to specify ethnic groups generally reflects the terminology used in the corresponding referenced articles.

Between 1991 and 1996-7, the prevalence of current smoking among adolescents rose substantially, by about one-half among 8th and 10th graders and about one-third among 12th graders (Johnston, et al., 2000). Cigarette use has declined somewhat since, but remains well above the 1991 levels.

In general, the probability and intensity of smoking increase with school grade and tend to be highest among whites (Kann et al., 2000; Blum, Beuhring, Shew, et al., 2000). Adolescents living in a single-parent family are more likely to report current smoking than are adolescents in two-parent families (Blum, Beuhring, Shew, et al., 2000; Norton, Lindrooth, & Ennett, 1998). Lower socioeconomic status has also been associated with a higher prevalence of smoking among adolescents (Blum, Beuhring, & Rinehart, 2000; Lowry, Kann, Collins, & Kolbe, 1996). However, Blum, Beuhring, and Rinehart (2000) estimate that knowing an adolescent's race/ethnicity, income, and family structure can explain only about 4% of the individual differences in amount of cigarette use among 7th and 8th graders and 7% of the differences in use among those in grades 9 through 12. Indeed, the current literature suggests that tobacco use is a complex behavior that is a product of influences at multiple interacting levels—including individual characteristics as well as family, peer, media, and policy factors.

Antecedents of Tobacco Use

Individual Antecedents

A number of longitudinal studies have suggested that attitudes and beliefs regarding smokers and smoking are important predictors of tobacco use in adolescence. Adolescents with more positive attitudes towards smokers (Dinh, Sarason, Peterson, & Onstad, 1995) or towards smoking and its consequences (Chassin, Presson, Sherman, & Edwards, 1991) are more likely to initiate a smoking habit. Dinh and colleagues (1995), for example, found that positive perceptions of smokers (e.g., healthy, cool, good-looking, independent) and negative perceptions of nonsmokers (e.g., uncool) among a predominately European-American sample of 1,663 children in the 5th and 7th grades predicted subsequent smoking in the 9th grade. Conversely, children who perceived smokers as 'dirty' or 'uncool' were less likely than their peers to become weekly smokers by the 9th grade. Between the 5th and 7th grades, children's perceptions of smokers tended to become more positive while their perceptions of nonsmokers became more negative. Notably, a general negative attitude toward smoking has also been associated longitudinally with an increased likelihood of smoking cessation among a sample of adolescent smokers in the Netherlands (Engels, Knibbe, deVries, & Drop, 1998).

The relationship between how adolescents think of smokers and how they think of themselves also appears to matter. Among 1,222 5th through 8th graders (44% white, 32% Hispanic, and 24% other ethnicities) in Los Angeles, a high degree of similarity between an adolescent's self-image and his/her image of smokers predicted smoking onset over a one-year follow-up (Aloise-Young, Hennigan, & Graham, 1996). Furthermore, the research suggests that adolescents who have an exaggerated perception of how common smoking is tend to be more likely than their peers to initiate a smoking habit. For example, Chassin and colleagues (1991) followed a sample of more than 4,000 middle and high school students, primarily white and middle class, over the course of one year. In this sample, an inflated perception of the prevalence of smoking in the community, at baseline, predicted adolescent smoking status one year later. Indeed, an evaluation of one successful smoking prevention program[4] suggests that at least some of these attitudes and beliefs—including perceived prevalence of smoking among peers and adults and accurate characterization of the immediate consequences of smoking—can be effective points of intervention (Botvin, et al., 1992). It is important to note that other antecedents—such as the attitudes, beliefs, and smoking habits of peers and parents as well as media messages about smokers and smoking—may help to shape these smoking-related perceptions and so may also be appropriate targets for intervention.

Poor school performance has also been found to predict later smoking. One longitudinal study (Wang, et al., 1999) selected non-smoking adolescents from a nationally representative sample of 12- to 15-year-olds, and followed these adolescents for three years. Adolescents with poorer school performance at the start of the study were more likely than their peers to become experimenters or regular smokers by follow-up three years later. This finding has been replicated in other populations, including a sample of 744 predominately white students followed from the 7th grade to the end of high school (Griffin, Botvin, Doyle, Diaz, & Epstein, 1999) and a sample of 401 younger children (84% white, 15% African American) followed from 5th to 7th grade (Jackson, Henriksen, Dickinson, Messer, & Robertson, 1998).

Cross-sectional studies suggest that employed adolescents may also be at an increased risk for smoking, but employment status has not yet been evaluated as a potential antecedent of adolescent tobacco use in a rigorous, longitudinal context. Nationally representative, cross-sectional data from the National Longitudinal Study on Adolescent Health indicate that 9th to 12th graders who work 20 hours or more per week are more likely than are their lesser- or non-working peers to smoke cigarettes (Resnick, et al., 1997). Employment status should be evaluated as a possible predictor of adolescent tobacco use in future rigorous studies.

Certain behavioral and emotional factors at the individual level have been found to predict tobacco use longitudinally. In addition to the association between poor school performance and tobacco use, Wang and colleagues (1999) also found that non-smoking adolescents who exhibited signs of depression at ages 12 to 15 years had an increased risk of becoming a regular smoker by follow-up at ages 15 to 18 years. A second study, of more than 2,000 14- and 15-year-old students in Australia, also found that signs of depression and anxiety predict smoking initiation longitudinally, but only among those adolescents whose friends smoke (Patton, et al., 1998b). The results of this Australian study further suggest that the relationship between depression and tobacco use is most pronounced among adolescent girls. While the reasons for this relationship have not been established, it is possible that depressed adolescents may try to self-medicate with tobacco and/or they may have a heightened susceptibility to peer smoking influences (Patton, et al., 1998b). Other behavioral and emotional factors may also be important. Lynskey and Fergusson (1995), for example, followed more than 900 New Zealand children for seven years, and found that children with conduct problems at age 8 were nearly twice as likely to become daily smokers by age 15, when compared with their peers without conduct problems at baseline. In an additional study, 5th graders and 7th graders (15% Asian, 32% Hispanic, 38% white, 4% black, 11% other or unknown) who displayed disruptive behavior were more likely than were their peers to initiate a smoking habit by 8th or 9th grade (Cohen, Richardson, & LaBree, 1994).

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[4] This intervention is discussed in further detail in a later section.

Personality also appears to play a role in predicting adolescent tobacco use. Some available studies regarding personality have lumped tobacco outcomes with alcohol and other drugs (e.g., Labouvie and McGee, 1986). At least one study, however, has evaluated personality as an antecedent specifically of tobacco use among adolescents. In this study, Masse and Tremblay (1997) followed 656 boys, all white, Canadian-born, French-speaking, of low socioeconomic status, and in schools in Montreal, from ages 6 to 15 years. Among these study participants, high novelty-seeking and low harm avoidance at ages 6 and 10 years predicted early onset of tobacco use between the ages of 12 and 15 years.

Finally, evidence suggests that there may be a genetic influence on tobacco use in adolescence. In one genetic study, McGue, Elkins, and Iacono (2000) studied 626 male and female 17-year-old twin pairs, primarily white, who were participants in the Minnesota Twin Family Study, a longitudinal study of adolescent twins and their parents. A comparison of the tobacco use behaviors of genetically identical twins and those of fraternal twins (who, on average, share the same number of genes as do non-twin siblings) suggests that genetic factors may account for sizable fraction of the variation in susceptibility to tobacco use. Importantly, this study also indicates that non-genetic factors play a key role in shaping tobacco use behaviors, too.

Family Antecedents

Family structure appears to be important in the context of adolescent tobacco use, as adolescents who live in a single-parent family are more likely to smoke than are their peers who live in two-parent families (Blum, Beuhring, Shew, et al., 2000; Norton, Lindrooth, & Ennett, 1998). Parental behaviors and attitudes also matter. Low parental monitoring (Jackson, et al., 1998; Cohen, et al., 1994) and inconsistent discipline of adolescent daughters by their mothers (Chassin, Presson, Todd, Rose, & Sherman, 1998) have been found to predict adolescent smoking. On the other hand, parental anti-smoking attitudes (Griffin, et al., 1999; Chassin, et al., 1998) and a positive, supportive parent-child relationship (Chassin, et al., 1991; Chassin, et al., 1998; Cohen, et al., 1994) appear to protect against adolescent smoking. For example, Cohen and colleagues (1994), followed more than 2,000 5th and 7th grade students through grades 8 and 9, respectively. The 5th grade sample was about evenly split across genders and was 15% Asian, 32% Hispanic, 38% white, 4% black, and 11% other or unknown ethnicity. The 7th grade sample had similar gender and ethnic distributions. The study's findings indicate that parenting factors at baseline were related to the likelihood that adolescents would initiate a smoking habit by follow-up, two to three years later. The protective parenting factors identified in this study include a positive parent-child relationship—characterized by whether parents provide positive feedback through praise, encouragement, and physical affection—and related to the extent of quality time and quality communication shared between parents and their children. Greater parental monitoring, defined by whether parents set curfews and know their children's whereabouts, was also associated with a decreased risk of smoking initiation among the adolescent participants.

Importantly, adolescents whose parents smoke are more likely to smoke themselves (e.g., Jackson, et al., 1998; Patton, et al., 1998b; Wang, et al., 1999). They are also less likely to quit smoking and more likely to relapse if they try to quit (Hansen, Collins, Johnson, & Graham, 1985; Patton, et al., 1998a). This finding, of a relationship between the smoking behaviors of adolescents and those of their parents, has been replicated in several longitudinal studies and in a variety of settings. There are a number of possible reasons for this association. As noted above, a heritable genetic susceptibility to tobacco use likely plays a role. Additionally, one longitudinal study, based on a nationally representative sample, provides compelling evidence that there may be a prenatal effect, such that a mother's smoking habits during pregnancy may affect the likelihood that her child will smoke during adolescence (Kandel, Ping, & Davies, 1994). This relationship was found among daughters but not among sons. Further possible explanations include parental modeling of smoking behavior and increased access to cigarettes at home. Interestingly, one longitudinal study, based on a predominately non-Hispanic white sample of three generations of mothers and daughters, suggests there may also be a "do as I say, not as I do" effect. This study found that daughters whose mothers smoke tend to view their mothers as less likely to punish smoking behavior than do daughters of non-smoking mothers, although mothers who smoke are *not* less likely than other mothers to report that they would discipline this behavior (Chassin, et al., 1998). Thus, parents who smoke but discourage their children from smoking may be sending mixed messages.

Peer Antecedents

Longitudinal studies have consistently found that adolescents whose friends smoke are more likely to smoke themselves (e.g., Chassin, et al., 1991; Cohen, et al., 1994; Jackson, et al., 1998; Wang, et al., 1999). There has been some debate, however, about whether having smoking peers actually encourages a teenager to initiate smoking (influence) or whether adolescents who smoke simply choose friends who share their smoking behavior (selection). While it is likely that selection plays a role, recent evidence suggests that the smoking habits of peers do influence a teenager's likelihood of smoking (Wills & Cleary, 1999). This finding was based on a two-year follow-up of a sample of nearly 2,500 urban and suburban 6th and 7th graders, who were 37% white, 29% African American, 23% Hispanic, 3% Asian American, 5% other ethnicity, and 3% mixed ethnicity. The reason behind the relationship between peer and adolescent smoking has not been established, but it is possible that peer smoking affects smoking risk via peer pressure, modeling, social reward or approval, or some combination of these or other mechanisms (Rowe, Chassin, Presson, Edwards, & Sherman, 1992). Indeed, additional longitudinal research (MacKinnon, et al., 1991), including one study based on a nationally representative sample of initially non-smoking adolescents (Wang, et al., 1999), has suggested that perceived peer approval of smoking behavior is predictive of adolescent smoking.

Peers also serve as a primary source of cigarettes. In a survey of 7th graders in a large, urban, primarily black school system, Robinson, Klesges, and Zbikowski (1998) reported that peers were the most common single source of cigarettes for both experimental and regular smokers, with 28.4% of experimental and 57.0% of regular smokers listing peers as a cigarette source.

Community Antecedents and Correlates

There has been some recent interest in neighborhood environments in relation to the use of tobacco and other drugs among teenagers. One study (Crum, Lillie-Blanton, & Anthony, 1996) investigated whether neighborhood environment is related to the probability that a child or adolescent will be offered tobacco or other drugs (exposure opportunity). Among the 1,416 Baltimore 6th and 7th graders (64% African American, 29% white, 7% other) who participated in the study, 28% reported that they had been offered tobacco. Crum and colleagues used a multi-item scale to measure neighborhood disadvantage according to such factors as availability of safe places and places to play, the extent of litter, homelessness, and poverty, and the degree of religiosity in the neighborhood, among others. They found that greater neighborhood disadvantage predicted an increased likelihood of having been offered tobacco by 6th or 7th grade. While this points to a potentially important neighborhood influence on adolescent smoking behaviors, further study will be needed to determine whether being offered tobacco is actually a strong determinant of tobacco use among adolescents (Crum, et al., 1996).

Societal Antecedents and Correlates

The possible targeting of cigarette manufacturer advertisements to minors has been a hot topic of debate in recent years, as tobacco advertisements have portrayed such cartoonish characters as RJ Reynold's Joe Camel. Although it is difficult to isolate the relationship between media exposure and smoking behavior among adolescents, there is a body of evidence that is suggestive of a link between tobacco industry promotion efforts and adolescent smoking. For example, Pierce, Choi, Gilpin, Farkas, and Berry (1998) conducted a longitudinal study based on a representative sample of California adolescents. In this study, adolescents who reported at baseline that they owned or were willing to own a tobacco promotional item, such as a tobacco company t-shirt, were more likely than their peers to progress toward smoking by follow-up three years later.[5] Based on these results, the authors suggest that exposure to tobacco promotional activities increases the likelihood that an adolescent will progress toward smoking. It is also possible that the possession of or willingness to possess a tobacco promotional item is simply a marker of a more general susceptibility to or acceptance of smoking, and that it is this more general susceptibility or acceptance that increases the probability of progression toward smoking.

In other suggestive studies, researchers have found that, historically between 1890 and 1997, sizable increases in smoking initiation in a given gender group in the United States tend to coincide with the introduction of tobacco marketing campaigns targeted to that group (Pierce & Gilpin, 1995). Further, Pucci and Siegel (1999) studied a random sample of 627 Massachusetts adolescents, who were 12 to 15 years old at baseline and 15 to 20 years old at follow-up. This study found that the distribution of brand-specific cigarette advertising in the magazines that adolescents report reading is associated longitudinally with the brand of cigarettes that new adolescent smokers choose to smoke. It is important to note that each of these findings is consistent with competing explanations, and so none is definitive. That media has proved a successful medium for *preventing* smoking in some cases (e.g., Siegel & Biener, 2000; Worden, et al., 1996), however, suggests further that media messages may indeed have the potential to modify adolescent smoking behavior—perhaps in either direction.

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[5] This study included individuals older than 18 years at follow-up. One-half of the sample, however, was 15-16 years old at follow-up.

Policy Antecedents and Correlates

Several policy approaches have been employed to try to prevent the initiation and/or promote the cessation of smoking among adolescents. These varied approaches include bans on tobacco sales to minors, bans on smoking on school grounds, and price or tax hikes on tobacco products.

Interventions to prevent tobacco sales to minors have been largely unsuccessful in affecting adolescent smoking behavior. A systematic review of the evidence by Stead and Lancaster (2000) included controlled studies, with and without random assignment, carried out in a variety of populations. Based on this review of published interventions, Stead and Lancaster concluded that regular enforcement of retailer behavior and, in some cases, simple retailer education, can successfully increase retailer compliance with the law. In these same studies, however, there was little impact on adolescents' perceived ease of access to tobacco or, most importantly, on their smoking behavior (see, e.g., Altman, et al., 1999; Rigotti, et al., 1997). Researchers have posited several possible reasons for this finding. Without complete compliance, a means of access to tobacco will remain (Stead & Lancaster, 2000), and adolescents may learn which stores are willing to sell to them or may buy tobacco in other communities with lesser enforcement (Rigotti, et al., 1997). Furthermore, retailer compliance is measured through compliance checks with test buyers, but these tests may not accurately measure adolescents' ease of access to tobacco. Actual underage buyers may differ from test buyers in lying about their age, using a fake ID, having an older individual buy tobacco for them, or being familiar to the vendor (Stead & Lancaster, 2000; Altman, et al., 1999; Rigotti, et al., 1997). Moreover, many adolescents obtain tobacco by means other than purchase in a store (Robinson, et al., 1998).

Other policy interventions may be more promising. Chaloupka and Grossman (1996) analyzed data from the national Monitoring the Future survey regarding adolescent smoking, adding information on cigarette price and tobacco control policies based on county of residence. Although not longitudinal, this study suggests that adolescents may be more sensitive to cigarette price than are adults, and that higher price is associated with both a decreased likelihood that an adolescent will smoke and a reduced amount of cigarette consumption among adolescents who smoke. Further, the data suggest that policies that limit smoking on school grounds are associated negatively with the amount that adolescent smokers smoke. In a follow-up analysis of the same data, Chaloupka and Pacula (1999) found that adolescent sensitivity to policies and to price may differ by race and gender, with males—and black males in particular—exhibiting the greatest sensitivity to price. A second policy study, also cross-sectional, evaluated the relationship between school smoking policies and smoking behavior among 4,807 7th graders (20% white, 27% black, 44% Hispanic) in Los Angeles and San Diego (Pentz, et al., 1989). The study authors found that more extensive anti-smoking policies at school are related to lower amounts of adolescent smoking, but that punitive consequences of policy violation are not. These studies are by no means conclusive; for example, the stringency of policies and price of cigarettes may simply reflect local societal views of smoking. However, these findings do suggest that it may be worthwhile to invest in further research to determine the effectiveness of interventions to increase cigarette taxes and to restrict smoking on school and surrounding grounds. An additional potential benefit of increasing the cigarette tax is that the resulting revenue can be reinvested in smoking-related efforts through funding of tobacco prevention and cessation programs.

Summary of Tobacco Use Antecedents

In summary, the available research indicates that tobacco use among adolescents is a complex behavior that reflects the influence of factors at multiple ecological levels. At the individual level, attitudes toward and beliefs about smokers and smoking are related to tobacco use, as are poor school performance, depression, conduct problems, and genetic factors. Cross-sectional studies further suggest that adolescents who work may be more likely to use tobacco when compared with their non-working peers.

Family factors also play a role. Greater parental monitoring and parental anti-smoking attitudes appear to protect against adolescent tobacco use. On the other hand, adolescents whose parents smoke are more likely to smoke themselves.

Having friends who smoke is also a risk factor for tobacco use among adolescents. This likely reflects a combination of influence (having friends who use tobacco may encourage an adolescent to use tobacco) and selection (adolescents may choose friends whose tobacco use behavior or propensity to use tobacco is similar to their own). Peers also serve as an important source of cigarettes.

Numerous factors at a societal and policy level have been related to adolescent tobacco use. Media messages appear to matter, as there is a suggestive body of research supporting a link between tobacco industry advertising and adolescent tobacco use. Moreover, adolescent tobacco use appears to be price sensitive, suggesting that the levels of price and tax on tobacco products may be related to adolescent tobacco use behaviors. Policies to limit smoking on school and surrounding areas may also limit the amount that adolescent smokers smoke, although further research is needed to verify this claim. It is noteworthy, however, that numerous interventions designed to prevent tobacco sales to minors have not shown an impact on adolescent tobacco use. These interventions appear to increase measured retailer compliance with the law without measurable effects on adolescent access to or use of tobacco.

Programs to Prevent Tobacco Use

School-Based Programs

Overall, school-based smoking prevention programs have had variable and generally modest success (Rooney & Murray, 1996). Programs that target the primary psychosocial factors related to tobacco use among adolescents have enjoyed success where more traditional programs—that simply provide factual information about the dangers of tobacco use or use fear-inducing strategies—have not (CDC, 1994a). With this in mind, the CDC has identified two school-based

"Programs that Work": Project Toward No Tobacco Use (Project TNT) and Life Skills Training.[6] Both have been evaluated with random assignment, experimental studies.

Project TNT is a 10-day, classroom-based program implemented in the 7th grade and followed by two booster lessons in the subsequent year (Dent, et al., 1995; Sussman, et al., 1993). This intervention program includes activities to address three major targets: (1) normative social influence (peer pressure), (2) informational social influence (statements by one's peer group, parents, tobacco advertisements, or others that suggest that tobacco use is widespread or confers a positive social image), and (3) inaccurate or incomplete knowledge about the physical consequences of tobacco use. Seventh graders in 48 junior high schools in California were randomized, by school, to receive their standard curriculum or one of four intervention curriculums—one each to target normative social influence, informational social influence, and knowledge of physical consequences, and a combined curriculum designed to target all three components. The target population included both urban and rural populations, and, although the study was restricted to majority white school districts, there was some diversity of ethnic groups, as the 7th graders were 60% white, 27% Hispanic, 7% black, and 6% Asian or other. At one- and two-year follow-ups, participants in the full TNT program showed attenuations in weekly use of both cigarettes and smokeless tobacco relative to the controls, who received their usual health curriculum. For example, between the 7th and 9th grades, the typical increase in the prevalence of weekly cigarette use with age was cut by more than half among TNT participants when compared with the controls. There was a 9 percentage-point increase among the controls, compared with an increase of just 4 percentage points among TNT participants. Notably, the physical consequences curriculum, more extensive than the traditional and ineffective information-based programs, was particularly successful in reducing use of smokeless tobacco.

In teaching resistance skills and general life skills, the Life Skills Training (LST) program aims to equip adolescents with the information and skills they need to resist social influences to smoke and to enhance personal characteristics associated with a decreased risk of smoking (Botvin, Baker, Dusenbury, Botvin, & Diaz, 1995; Botvin, et al., 1989; Botvin, et al., 1992). The longest-term follow-up evaluation of the LST curriculum was conducted among 56 schools in a primarily white, high socioeconomic status area in New York state (Botvin, et al., 1995). Schools were randomized to LST or usual curriculum conditions. The LST intervention included 15 class periods in the 7th grade, 10 in the 8th grade, and 5 in the 9th grade. Class sessions were designed to enhance student's cognitive-behavioral skills for: self-esteem building, resistance to media influences, anxiety management, effective communication, development of personal relationships, and resistance to peer and other pressures to use tobacco. Program activities included demonstration of skills, behavioral rehearsal, feedback, and reinforcement, and assignments to practice skills outside of class. Students were followed for an average of 6 years. At follow-up, the prevalence of monthly, weekly, and heavy (one or more packs per day) smoking was lower in the LST condition than in the control group, particularly among those students in classrooms in which a more complete implementation (at least 60%) of the program was delivered. Among LST subjects who had been exposed to at least 60% of the program, the prevalences of monthly and weekly cigarette smoking and the prevalence of heavy smoking were at least 25% lower than in the no-intervention control group. For example, 27% of controls reported weekly smoking at follow-up, compared with 20% of students in the high-implementation group, and 12% of controls smoked at least a pack a day, compared with 9% of high-implementation program participants. These findings are particularly noteworthy given that many programs have found a rapid deterioration of impact on smoking behavior as the time since intervention increases (e.g., Bell, Ellickson, & Harrison, 1993). It may be that the extent of intervention, extensive booster sessions, comprehensive nature of the program, and consideration of implementation fidelity bolstered the success of the LST program over the long term (Botvin, et al., 1995). In shorter follow-up studies, the LST program has shown marked success in a diversity of settings, including urban schools that are primarily Hispanic (Botvin, et al., 1992) or black (Botvin, et al., 1989). LST has also had success in the prevention of use of alcohol and other drugs (Botvin, et al., 1995).[7]

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[6] http://www.cdc.gov/nccdphp/dash/rtc/eval7.htm and http://www.cdc.gov/nccdphp/dash/rtc/eval6.htm, accessed 12/14/2000.

It is important to note a few caveats to the LST findings. First, the subset of program participants who were exposed to at least 60% of the program may not be comparable to the whole set of students who were initially randomized to the program and control conditions. This would eliminate the analytical benefits of the original randomization of participants to the study conditions. Second, as may be true for other researchers in the field, Botvin and colleagues do have a potential conflict of interest since they are profiting from the sales of their program protocol (Cohn, 2001). Finally, recently published findings from the Hutchinson Smoking Prevention Project (HSPP; Peterson, Kealey, Mann, Marek, & Sarason, 2000) add a cautionary note to our optimism about school-based smoking prevention programs that focus on social influences. In the HSPP, 40 school districts, in small- to medium-sized communities in rural and suburban areas of the state of Washington, were randomly assigned to a social influences prevention program or usual curriculum control. The authors state that the distributions of gender, percent minority, percent in single-parent families, and percent of parents who graduated from high school among study participants were similar to those distributions among all children in the U.S. The intervention began in the third grade and continued through the tenth grade, with teacher-led sessions designed to focus on skills for identifying social influences to smoke, skills for resisting these influences, and correction of exaggerated normative perceptions about smoking. Other goals included motivating students to desire to be smoke free, promoting self-confidence in refusal skills, and enlisting positive family influences. In high school, the program distributed self-help tobacco cessation materials to students, and newsletters regarding tobacco resources and current events to teachers.

Although there was wide variation in smoking patterns among the studied school districts, Peterson and colleagues (2000) found no substantial difference in smoking prevalence between the control and experimental conditions, either at 12th grade or two years after high school. This trial was quite large and quite rigorous. Further studies should evaluate which components of the LST program appear to be exerting a positive influence on adolescent smoking; it may be that differences between the LST and HSPP interventions—such as specific program content, delivery, target population, or starting age—may account for the discrepancy in success. The HSPP trial does, however, highlight the importance of continuing to seek novel and expanded intervention strategies as we implement and evaluate those, like LST and Project TNT, that have met with success to date.

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[7] Please see the Knight report on mental health and disorders (Zaff & Calkins, 2001) for a description of the relevant findings for alcohol and other drugs.

Beyond School-Based Programs

Augmenting a school-based intervention with a community intervention may enhance the impact on adolescent smoking behavior beyond that of the school-based program alone. One randomized, controlled trial among eight pairs of small rural communities in Oregon examined the effect of the addition of several community components to supplement a school-based tobacco-prevention program (Biglan, Ary, Smolkowski, Duncan, & Black, 2000). The study sample was nearly evenly split across genders, and was approximately 85% white, 8% Hispanic, 5% Native American, 1% African American, and 1% Asian. The program's community components included media advocacy to encourage adults in the community to support adolescent tobacco-prevention efforts, community youth anti-tobacco activities, activities to help parents to express disapproval of tobacco use to their children, and efforts to reduce tobacco access in the community. Supplementation of the school-based program with the community intervention dampened the upward trend in smoking prevalence—observed both in this study's control group and in the U.S. as a whole—over the course of five annual surveys of 7th and 9th graders in each community. In communities that received only the school-based intervention, the prevalence of weekly smoking among 7th and 9th graders increased by 6 percentage points, from 8% to 14%, from the first to the final annual survey. In contrast, communities that received the school and the community-based component saw only a 2 percentage-point increase, from 10% to 12%, over the same time period.

A second study (Worden, et al., 1996) evaluated a mass-media campaign designed to encourage a positive perception of non-smoking and a negative perception of smoking, to teach cigarette refusal skills, and to remedy inflated perceptions of the prevalence of smoking among peers. This intervention was targeted to communities with lower adult educational attainment and focused on adolescent girls. Two small metropolitan areas received both the mass-media campaign and the school-based program, and two other, similar communities received the school-based program only, in a quasi-experimental design. The media program designers invested heavily in pre-testing the media spots among samples of the targeted audience. About 2,500 subjects, nearly evenly split across genders, were followed annually starting from grades 4-6 to grades 8-10, and then again two years later in grades 10-12. (The ethnic distribution of the sample was not detailed in the published program evaluation.) Compared with adolescent girls in the school-based-only intervention, adolescent girls in the communities that received the media campaign in addition to the school program showed a 44% relative reduction in weekly smoking prevalence: 29.4% of school-based-only participants, compared with just 16.5% of school-plus-media program participants, reported smoking during the week prior to the 12th grade survey. There was a similar but not statistically significant difference for adolescent boys. Among both boys and girls, school-plus-media intervention communities also showed a smaller rise than did school-based-only communities in positive attitudes toward smoking, perceived prevalence of peer smoking, and intentions to smoke. In general, the factors that appear to distinguish effective media campaigns from unsuccessful ones are high levels of intensity and duration of the media exposure and targeting of the campaign to a relatively high risk group (Sowden & Arblaster, 2000). There is some evidence to suggest that these media demonstration project results may be applicable also to government-funded, statewide media campaigns (Siegel & Biener, 2000), although more research will be necessary to investigate this important question.

Summary of Programs to Prevent Tobacco Use

In summary, programs that are purely information-based and designed to induce fear of the consequences of tobacco use have not tended to meet with success in reducing tobacco use among adolescents. Yet certain multi-component school-based programs, designed to target the primary psychosocial factors related to adolescent tobacco use, have shown promising results. The CDC has chosen to highlight two such programs, Project TNT and Life Skills Training, in their "Programs that Work" series. Each of these programs has shown promising impacts on adolescent tobacco use in the context of randomized, controlled trials.

However, there is an important caveat to these findings. A recently published evaluation of a school-based program that targeted social influences to smoke did not find reductions in adolescent tobacco use. Further study is needed to explain the success of the above programs given the failure of this high-quality, long-term, social influences program.

Additional studies suggest that supplementing school-based programs with community program components may be a useful approach. A handful of studies have found that the augmentation of a school-based program with carefully constructed anti-tobacco media messages and other community activities results in an enhanced reduction in tobacco use over and above that associated with the school-based program alone.

Areas for Future Research

Of the several health behaviors to be described in this chapter, tobacco use has the most extensive body of relevant research, carried out in the widest variety of populations and settings. That said, much of the literature on tobacco use during adolescence relies on samples that are primarily white, and the vast majority of studies focus only on in-school youth. There is a need, then, for further research on a diversity of ethnic and socioeconomic groups, as well as on the out-of-school population. Moreover, there are several topical areas relevant to adolescent smoking behavior that will require further rigorous investigation. First, smoking cessation among adolescents deserves additional research attention to elucidate both the longitudinal predictors of voluntary cessation and the efficacy of smoking cessation programs among adolescents. Smoking cessation is a vitally important goal, as cessation leads to a reduction over time in the risk of adverse outcomes associated with tobacco use (CDC, 1990). With a few noted exceptions, the studies cited in this review tend to focus on smoking initiation or simply on smoking prevalence, which reflects the combined effects of initiation and cessation. Indeed, researchers have noted that little research attention has been given to smoking cessation among adolescents—and that the few interventions published to date have reported little or no success (Myers, 1999). Moreover, adolescent substance abuse treatment programs rarely address the problem of tobacco use directly (Myers, 1999).

Second, further study of the antecedents of the use of alternative forms of tobacco (i.e., cigars, smokeless tobacco) would also be informative. Research in this area is particularly important in light of evidence that fewer young people are aware of the dangers of smokeless tobacco than are aware of the dangers of cigarette smoking (DHHS, 1994).

Third, neighborhood, community, and societal antecedents deserve further research interest. Interesting leads point to factors such as neighborhood disadvantage and tobacco offers, price or tax hikes and stringent school policies regarding smoking, and media portrayal of tobacco use as potentially important antecedents of adolescent tobacco use. These and other factors related to the broader context of adolescent development merit attention in future studies.

Finally, prevention and intervention programs should target the antecedents of adolescent smoking behavior that the current longitudinal observational studies suggest may be important. For example, programs should consider targeting parental smoking, a strategy that would impart additional health benefits for parents and their children above and beyond any successful prevention of adolescent smoking.

In order to reach the Healthy People 2010 objective of reducing the prevalence of all adolescent tobacco use to just 21% (DHHS, 2000a), interventions likely will need to target smoking behavior on several fronts. The continued high prevalence of adolescent tobacco use indicates that effective interventions need to be identified and implemented widely.

Physical Activity and Nutrition

Importance

Second only to tobacco use, insufficient physical activity and poor nutrition combine to make up the second leading preventable cause of death in the U.S., together accounting for at least 300,000 deaths in 1990 (McGinnis & Foege, 1993). This substantial impact reflects the shared influence of physical activity and dietary factors on such prevalent morbidities as obesity, coronary heart disease, stroke, hypertension, diabetes, and selected cancers (CDC, 1996a; Goran, Reynolds, & Lindquist, 1999; Ludwig, Peterson, & Gortmaker, 2001; McGinnis and Foege, 1993; Story & Neumark-Sztainer, 1999). Physical activity and nutrition have also been associated with osteoporosis (CDC, 1996a). Inadequate dietary composition, in particular, is further related to delayed growth and sexual maturation, iron deficiency/anemia, dental caries, decreased concentration and poor school performance (Alvarez, 1995; CDC, 1996a; Story & Neumark-Sztainer, 1999; Szpunar, Eklund, & Burt, 1995). Physical activity has been associated also with decreased anxiety and stress (Story & Neumark-Sztainer, 1999) and may serve to buffer the effects of stress on health (Brown & Siegel, 1988).

While some of the health outcomes related to physical activity and nutrition generally onset during adulthood, many—such as obesity, diabetes, anemia, and dental caries—can arise throughout the lifespan. For this reason, fostering good physical activity and dietary habits early in life is essential. Notably, there have been dramatic increases over recent years in the percentages of adolescents who are obese (National Center for Health Statistics, 2001; Troiano & Flegal, 1998) or have non-insulin dependent diabetes mellitus (Pinhas-Hamiel, et al., 1996)—and so are at increased risk of suffering the numerous health, social and economic consequences associated with these conditions (Dietz, 1998; Gortmaker, Must, Perrin, Sobol, & Dietz, 1993).

Since both physical activity and dietary behaviors appear to track somewhat from adolescence into adulthood (Kelder, et al., 1994; Malina, 1996), the establishment of positive physical activity and dietary behaviors in adolescence is likely to be important also to health behavior patterns in adulthood, and thus to future health. However, many adolescents are not active enough, and many are not consuming a healthy selection of foods.

Prevalence and Trends

Nationally, in 1999, approximately one-third of high school students reported that they did not take part in vigorous physical activity on at least 3 days during the preceding week (Kann, et al., 2000). This is consistent with the findings for 7th-12th graders, based on the 1996 National Longitudinal Study of Adolescent Health, that indicate that one-third of adolescents failed to meet the current public health recommendations of three or more sessions of continuous moderate to vigorous physical activity per week (Gordon-Larsen, McMurray, & Popkin, 1999). Over time, there has been a decreasing trend in the percentage of high school students who attend physical education (PE) classes on a daily basis, with about one-fifth reporting daily attendance in 1999 (Kann, et al., 2000).

Consistent findings across national surveys show that adolescent males tend to be more physically active than adolescent females and are more likely to have played on a sports team in the prior year (Gordon-Larsen, et al., 1999; Kann, et al., 2000; Ross, Dotson, Gilbert, & Katz, 1985). Even among those enrolled in PE classes, males tend to get more exercise during an average PE class than do females (Kann, et al., 2000). The national findings also indicate differences by ethnic background, especially among females, with white females reporting more physical activity than their Hispanic or black peers, and white students getting more exercise than black students during an average PE class (Gordon-Larsen, et al., 1999; Kann, et al., 2000). Hispanic and black students also exhibit a higher level of physical *in*activity than do white students, reporting greater time devoted to television viewing (Kann, et al., 2000). Moreover, adolescents with a high family income are more likely to report frequent physical activity and less likely to report frequent inactivity than are those with a low family income (Gordon-Larsen, McMurray, & Popkin, 2000). Finally, national surveys consistently indicate that physical activity among adolescents declines precipitously with age, particularly among females. For example, nationally in 1996, 47.0% of 16 to 17 year-old female students failed to participate in moderate to vigorous physical activity at least 3 times a week, compared with 25.5% of female students ages 12 to 15 (Gordon-Larsen, et al., 1999). Among adolescent males, 27.3% of 16 to 17 year-olds failed to meet this criterion, compared with just 16.0% of 12 to 15 year-olds. Enrollment and attendance in PE class also decrease notably with age (Kann, et al., 2000); this trend is consistent with dramatic decline across grades in the fraction of schools that require physical education, from 25% for 8th graders to just 5% for 12th graders (Burgeson, Wechsler, Brner, Young, & Spain, 2001).

The picture for nutrition is more complex, as there are numerous dietary components that are vital to health. Generally speaking, national studies suggest that adolescents are consuming too much fat, sodium, and sugar and not enough fiber (Gleason & Suitor, 2001; Munoz, Krebs-Smith, Ballard-Barbash, & Cleveland, 1997; Siega-Riz, Carson, & Popkin, 1998). An analysis of the 1989-1991 national USDA survey of dietary habits (the Continuing Surveys of Food

Intakes by Individuals) indicated that 7.1% of adolescent males and 18.4% of adolescent females did not meet the recommended food intake for any of the major food groups, and an additional 24.7% of males and 35.1% of females met only one recommendation (Munoz, et al., 1997). Less than 2% of adolescent males and less than 1% of adolescent females met all five food group recommendations. Among the five food groups, children and adolescents ages 19 and younger were least likely to meet the recommendations for fruit, grain, or dairy (Munoz, et al., 1997).

Over the past several decades, there have been drops in adolescent consumption of raw fruits, non-potato vegetables, and calcium-rich dairy sources, with a concurrent, sharp rise in the consumption of soft drinks (Cavadini, Siega-Riz, & Popkin, 2000). That soft drinks have increasingly become the beverage of choice among adolescents is particularly noteworthy in light of recent findings that soft drink consumption is associated with an increased risk of obesity among adolescents (Ludwig, et al., 2001). The replacement of milk consumption with soft drink intake also may have implications for other outcomes, including osteoporosis and dental caries (Cavadini, et al., 2000).

Nationally representative surveys indicate that male adolescents are more likely than are female adolescents to meet dietary recommendations for iron, calcium, and folate (Cavadini, et al., 2000). Overall, in fact, female adolescents have a particularly high prevalence of insufficient vitamin and mineral intake, as many do not consume enough vitamins A and E, zinc, folate, magnesium, iron, and phosphorous (Gleason & Suitor, 2001). Nationally, male adolescents are also more likely than are their female peers to meet the food group recommendations for grains, dairy, and meat, and they also have a higher average intake of vegetables (Munoz, et al., 1997). On the other hand, female adolescents tend to eat more fruit (Munoz, et al., 1997).

There are also ethnic and socioeconomic differences in dietary patterns. Among all U.S. children and adolescents ages 19 or younger, white children are more likely than are black or Hispanic children to meet recommendations for intake of grains and dairy, but less likely than black children to meet recommendations for vegetable intake (Munoz, et al., 1997). Black adolescents are more likely than are white adolescents to eat an inconsistent meal pattern (defined as consumption of only one meal, with or without snacks, or snacks only, on three consecutive survey days), which is associated with a lesser quality diet (Siega-Riz, et al., 1998). Intakes of fruit and dairy tend to increase with increasing socioeconomic status (Lowry, et al., 1996; Munoz, et al., 1997), and higher socioeconomic status has been associated with decreased consumption of high-fat foods among girls (Lowry, et al., 1996). Finally, vegetable and meat consumption appear to increase, and fruit intake to decline, with increasing age among both male and female children and adolescents (Munoz, et al., 1997). Older adolescents are more likely than younger adolescents to exhibit an inconsistent meal pattern (Siega-Riz, et al., 1998).

Overall, while many adolescents are matching or exceeding the guidelines for physical activity, a substantial fraction is not active enough—and many more are not consuming a diet with adequate nutrition. These circumstances point to a critical need for research to elucidate the determinants of physical activity and a healthy diet among adolescents. Surprisingly, to date, almost no rigorous, longitudinal, observational (i.e. non-intervention) studies have been published on this topic. The bulk of the current observational literature is cross-sectional and/or focussed on age groups other than adolescents.

Antecedents and Correlates of Physical Activity and Good Nutrition

Physical Activity

Individual Antecedents and Correlates

In one of the few longitudinal studies of physical activity among adolescents, Reynolds, et al. (1990) followed 233 adolescent boys and 141 adolescent girls in Northern California for 16 months, beginning in the 10th grade. The study population was derived from control group participants in the trial of the Stanford Adolescent Heart Health Program, in which participants overall were 69% white, 2% black, 13.1% Asian, 6.4% Latino, and 9.6% other (see Killen, et al., 1989). Among males, baseline levels of physical activity and intention to exercise were significant predictors of physical activity at follow-up. Among girls, perceived ability to be physically active (self-efficacy) and intention to exercise (measured by reported intention to exercise regularly in the future, to stay in good physical shape, and to participate in organized sport in the next school year) at baseline predicted physical activity 16 months later.

A second study (DiLorenzo, Stucky-Ropp, Vander Wal, & Gotham, 1998) followed 54 girls and 57 boys for three years beginning in the 5th and 6th grades. The study participants were predominately Caucasian and from middle class families. Consistent with the study described above, baseline self-efficacy for physical activity was predictive of physical activity at follow-up among adolescent girls. Among adolescent boys, baseline knowledge about exercise predicted physical activity at follow-up, as did baseline level of physical activity. Adolescent girls whose mothers had fewer barriers to exercise tended to show higher levels of activity than did girls whose mothers had more barriers.

Several other potential determinants of adolescent physical activity have been proposed based on theory or on documented cross-sectional relationships. These factors are deserving of further research attention in a rigorous, longitudinal context, but have not yet been identified as causal determinants of physical activity behavior in adolescence. At the individual level, attitudes toward and enjoyment of physical activity, extent of sedentary behavior and television viewing, achievement orientation, and depression all have shown cross-sectional relationships with physical activity (Bungum & Vincent, 1997; DiLorenzo, et al., 1998; Sallis, Prochaska, & Taylor, 2000). Furthermore, adolescents have cited time constraints, mood, lack of energy or self-discipline, and discomfort as perceived barriers to physical activity (Allison, Dwyer, & Makin, 1999); however, whether the existence of these barriers actually predicts physical activity behaviors remains to be elucidated. Physical health status has also been proposed as a likely determinant of physical activity among adolescents (Kohl & Hobbs, 1998).

Family and Peer Correlates

Cross-sectional analyses suggest that peer physical activity and support may be related to adolescent activity (Bungum & Vincent, 1997; DiLorenzo, et al., 1998; Reynolds, et al., 1990), although the findings have been inconsistent (Sallis, et al., 2000). Family context is likely to be important to adolescent activity, as the physical activity of adolescents appears to correlate with that of their siblings and their parents (DiLorenzo, et al., 1998; Rossow & Rise, 1994; Sallis, et al., 2000), as well as with parental support and nurturing (Bungum & Vincent, 1997; DiLorenzo, et al., 1998; Sallis, et al., 2000). These findings suggest that peer and family factors should be considered in future high-quality, longitudinal studies.

Neighborhood, Community, and Broader Environmental Correlates

There has been a growing interest in the possible effects of neighborhood, community, and broader environmental factors—including access to facilities and safe opportunities to exercise both inside and outside of school—on physical activity in adolescence. Opportunities to exercise in the school context appear to vary by the socioeconomic status and urbanicity of the school community. Lower income communities are less likely than are middle, mixed, or upper income communities to have a playground, gym, or sports field in their schools; and urban schools are less likely to have a gym than are rural or, especially, suburban schools (Stillman, Truslow, & Woods, 2000). Future longitudinal research should examine whether these resources affect overall physical activity among adolescents.

Opportunities to exercise outside of school are also likely to be important, as the vast majority of the time that 5th-12th graders spend engaging in physical activity occurs outside of PE class, mostly in the community (Ross, et al., 1985). Seasonal factors appear to influence patterns of physical activity outside of school. The activity level of 5th-12th graders drops markedly during the fall, reaching a low in the winter at about half of the level of physical activity seen during the summer months, and then increases as the weather warms (Ross, et al., 1985). Moreover, the percentage of time spent outdoors is correlated with physical activity among younger children (Sallis, et al., 2000) and so may also be relevant for adolescents. Participation in community sports and opportunities to exercise are correlated with adolescent physical activity (Sallis, et al., 2000), but have not been investigated longitudinally. Finally, little or no research attention has been paid to the potential influence on adolescent activity of several theoretically important environmental variables, including access to parks, bike trails or lanes, exercise facilities and programs, and the physical safety of the environment (Kohl & Hobbs, 1998; Sallis, et al., 1992).

Nutrition

The literature on determinants of dietary intake during adolescence is even sparser than that on physical activity, and is essentially limited to descriptive and cross-sectional analyses, as well as theory and extrapolations from the literature on younger children. The bulk of the literature on adolescents has focused on eating disorders and dieting behavior rather than on the antecedents of diet composition and the selection of nutritious foods (Birch & Fisher, 1998). [A description of the literature on eating disorders can be found in the Mental Health and Externalizing Disorders chapter of this report and so will not be included here.]

Individual Correlates

The findings of a cross-sectional study by Contento, Michela, and Goldberg (1988) suggest that adolescents who emphasize health considerations when choosing foods have a healthier diet than those who emphasize other factors, like taste. The study population included 355 11- to 18-year-olds, drawn from 15 urban, suburban, and exurban schools in the New York metropolitan area. Study participants were of a wide socioeconomic range and were 47% white, 21% black, 20% Hispanic, and 12% Asian, Native American, or other. Although most of these adolescents valued taste when considering food choices, one subgroup was found to place a particularly heavy emphasis on taste, while, at the other extreme, another group placed its highest emphasis on the health-related qualities of foods. Adolescents in the taste-focused group tended to consume larger amounts of fat and sugar and less calcium and vitamins A and C than did adolescents in the health-oriented group. Further research should assess this relationship in a longitudinal context. What factors *shape* food-choice considerations also remains to be considered. Among younger children, at least, familiarity of foods is one factor that is associated with dietary consumption (Birch & Fisher, 1998).

A second, cross-sectional study found that work status appears to be related to the dietary habits of older adolescents (Skinner, Salvetti, & Penfield, 1984). Among 148 16- to 18-year-olds (84% white) in Tennessee, those who worked on the day of the survey were less likely than those who neither worked nor participated in extracurricular activities that day to make it home for dinner. Working adolescents instead tended more often to eat out or to skip dinner. The study further reported that working adolescents consumed fewer vegetables and less calcium, riboflavin, vitamin C and vitamin A than did their non-working peers. Notably, however, this study was not able to control for socioeconomic status. Moreover, it is possible that time constraints of any sort, including but not limited to work, may influence nutrition among adolescents.

Finally, a nationally representative, cross-sectional survey suggests that adolescents who do not attend school are more likely than are their in-school peers to exhibit an inconsistent meal pattern, associated with a less nutritious diet (Siega-Riz, et al., 1998).

Peer and Family Correlates

Modeling of healthy food selection by peers has been shown to affect the food selection of preschool children (Birch & Fisher, 1998). Although theory would suggest that peers likely have an influence on the food intake of adolescents, there has been little research on this issue (Crocket & Sims, 1995).

The family context is also likely to be important to adolescent dietary composition, as the family is a primary setting for food purchase, selection, and consumption during development. Family structure appears to matter. Nationally representative survey data indicate that adolescents who reside in a single-parent home are more likely than are their peers to have an inconsistent meal pattern, which, according to nutritional content analysis, tends to be less healthy and nutrient-dense than are more consistent meal intakes (Siega-Riz, et al., 1998). Some studies suggest that nutritional intake among adolescents is related to that of their parents. One longitudinal study followed 597 Norwegian high school students from 10th to 12th grade, and found that maternal sugar intake at baseline predicted adolescent sugar intake two years later, after controlling for adolescent sugar intake at baseline (Astrom, 1998). At least one cross-sectional study, also Norwegian and based on a sample of 337 families, further suggests that parental fat intake is highly related to adolescent fat intake (Rossow & Rise, 1994). Among younger children, parental control of food as a reward or a requirement tends to influence which foods children prefer and select (Birch & Fisher, 1998). These suggestive findings indicate that longitudinal studies designed to elucidate the potential influence of family factors on adolescent food preference and selection may be critical to our understanding of adolescent nutrition.

Neighborhood, Community, and Broader Environmental Correlates

As with physical activity, there has been a budding interest in the possible influence of broader environmental factors on adolescent nutrition. Ease of access to healthy foods and ease of access to *un*healthy foods have been of particular concern. One cross-sectional study suggests that the healthiness of diets among members of a community (not limited to adolescents) is related to the availability of healthy foods in that community's stores (Cheadle, et al., 1991). Importantly, however, this study does not distinguish between whether available foods in stores actually influence dietary intake or simply reflect the community's demand for certain foods. In another cross-sectional study, the availability of fruits and vegetables at home and in schools was associated with the fruit and vegetable consumption of third-grade students (Hearn, et al., 1998). Notably, preliminary research, based on a survey and on focus groups, suggests that lower-income elementary-school-aged children tend to find fewer fresh fruits and vegetables available at school and at home than do their higher-income peers (Hearn, et al., 1998; Kirby, Baranowski, Reynolds, Taylor, & Binkley, 1995). The degree of availability of healthy foods to adolescents, in particular, and any effect of availability on adolescent nutrition, remain to be evaluated.

Ease of access to *un*healthy foods is another possible environmental determinant worthy of investigation. A nationally representative survey of public and private schools in 2000 found that 74% of middle and junior high schools and nearly all—98%—of senior high schools have either a vending machine or a school store, canteen, or snack bar available to students (Wechsler, Brener, Kuester, & Miller, 2001). In the majority (71%) of these schools, students have access to these, largely unhealthy, food sources even during the school lunch period. Moreover, one-half of middle and junior senior high schools and nearly three-fourths (72%) of senior high schools in the nation have contracted with a company to sell soft drinks at the school (Wechsler, et al., 2001). The option to leave school to buy food may also increase the ease of access to unhealthy foods for some students (Story, Hayes, & Kalina, 1996). These findings are particularly interesting in light of the sharp rise over recent years in soft drink consumption among adolescents; however, the effects of this high accessibility of unhealthy foods and beverages are yet to be documented in the literature.

Media messages are another potentially important antecedent of adolescent nutrition, but this issue remains relatively untapped in the research literature (Birch & Fisher, 1998). Story and Faulkner (1990) evaluated the nutrition-relevant content of commercials and television series during prime time in 1988 and found that the 'prime-time diet' was made up of foods that were predominately of little nutritional value. Among all food references in prime time television shows, 60% were for low-nutrient drinks and sweets. Just over one-third of prime time commercials were advertisements for foods, most commonly for fast food restaurants. There were almost no commercials for fruits and vegetables. Notably, more hours of television watching has been associated with obesity among children (Kohl & Hobbs, 1998); however, whether this relationship reflects decreased physical activity, increased opportunity for food consumption, media influence, or some combination of these or other factors is unknown.

Policy Correlates

At the policy level, schools participating in the National School Lunch and Breakfast Programs are required to serve meals that are consistent with national dietary guidelines (Harnack, et al., 2000). The programs appear to have some influence, as consumption of school lunch is associated with a more consistent meal pattern, and thus a healthier diet on average, among adolescents (Siega-Riz, et al., 1998). With regard to specific nutritional content, children and adolescents who participate in school meal programs have a greater consumption of milk, fruits, and vegetables and a lower sugar intake, when compared with non-participating youth; however, they also tend to have higher intakes of total and saturated fat (Gleason & Suitor, 2001). Of note, many of the adolescents who are eligible to participate in the National School Lunch Program do not, perhaps because of a perception of stigma (Crockett & Sims, 1995).

In another policy strategy, some localities have implemented policies that restrict vending machine access during school meals, in response to the federal law that mandates state agencies and school food authorities to limit the sale of competitive foods during the USDA breakfast and lunch programs (see Stillman, et al., 2000). However, some researchers have suggested that this federal legislation is not sufficient, as it does not limit sales from other sources—including vending machines, school snack bars and stores—either outside of the food service area at any time, or in any location during hours outside of school meal periods (Harnack, et al., 2000; Story, et al., 1996). Indeed, surveys of schools in the Minneapolis/St. Paul area (Harnack, et al., 2000; Story, et al., 1996) suggest that food items, including carbonated beverages and hard candy, frequently are sold immediately outside the food service area, even on an adjoining wall. Moreover, a sizable fraction of adolescents in the surveyed schools regularly buy a la carte foods, with the least healthy foods being the most popular purchases. Although more research is necessary to elucidate any influence of the availability of competitive foods on adolescent nutrition and the effectiveness of various policy options, many researchers and nutrition-related groups are urging for more stringent restrictions at the national level (Story, et al., 2000).

Summary of Antecedents and Correlates of Physical Activity and Nutrition

In summary, there is a great need for further research, as the bulk of the existing literature regarding factors associated with physical activity and nutrition among adolescents is cross-sectional in design. This literature does provide several leads, pointing to factors that merit attention in future well-designed longitudinal studies. For physical activity, these factors include intention to exercise, perceived ability to be physically active (self-efficacy), attitudes toward physical activity, time constraints and motivational factors. The available literature further suggests that the physical activity behavior patterns of peers and of family members may be important. In theory, the availability of safe and enjoyable opportunities to exercise, in and out of school, may also affect physical activity among adolescents.

The literature regarding adolescent nutrition—which is essentially entirely cross-sectional—suggests that adolescents who consider health factors when selecting foods have a healthier diet than do their peers who emphasize other considerations, like taste. Cross-sectional studies have further suggested that adolescents who work and those who are not in school may be less likely to consume a nutritious selection of foods. Dietary patterns among adolescents are also associated with those of their family members, indicating that family nutrition is a potential antecedent to adolescent nutrition. In theory, ease of access to healthy foods and ease of access to *un*healthy foods, both in school and at home, may influence dietary intake among adolescents. The effects of policies regarding the availability of healthy and unhealthy foods at schools are deserving of further investigation.

Despite numerous interesting leads, then, there exists little rigorous observational research to inform the development and targeting of programs designed to promote physical activity and good nutrition among adolescents. However, some successful programs have been implemented and evaluated in the published literature.

Programs to Promote Physical Activity and Good Nutrition

The majority of programs to promote physical activity and a healthy diet have been school-based, and most have focused on younger children (Lytle & Achterberg, 1995; Marcus, et al., 2000; Story & Neumark-Sztainer, 1999). Some, though, have focused on adolescents. Many are multicomponent programs that aim to reduce cardiovascular disease risk by targeting physical activity and dietary behaviors together, sometimes also in combination with smoking (Stone, et al., 1998). In general, simple health education alone has not proved effective in changing behavior (Sallis, et al., 1992; White & Skinner, 1988), and programs that include behavioral approaches have tended to meet with more success.

School-Based Programs

The Child and Adolesent Trial for Cardiovascular Health (CATCH) is likely the most extensively implemented and evaluated example of a multicomponent, school-based program that includes an educational curriculum along with a behavioral component and school environmental change (Luepker, et al., 1996; Nader, et al., 1999). Although the program was implemented during elementary school, behavioral effects were sustained to a follow-up three years after the intervention's completion, when the participants were pre- and young adolescents in the 6th, 7th, and 8th grades. Ninety-six schools in California, Louisiana, Minnesota, and Texas were randomized to the CATCH intervention (56 schools) or control group (40 schools). CATCH schools received school food service modifications and food service personnel training to improve the nutrition of school meals, PE interventions and teacher training to increase the amount of fun moderate-to-vigorous physical activity during PE classes, and classroom curricula to address eating habits, physical activity, and smoking. Control schools received their usual food service, PE classes, and health curricula. Three years later, data were collected for 3,714 middle-school students (73% of the initial cohort), who were 69% white, 14% Hispanic, 13% African American, and 4% other. The experimental group differences observed in dietary behaviors at the end of the intervention were maintained over the transition to middle school.

When compared with the control group at the three-year follow up, the CATCH intervention group, on average, obtained a smaller proportion of dietary energy from total fat (30.6% vs. 31.6%) and from saturated fat (11.3% vs. 11.8%). Nader and colleagues (1999) note that, although these differences appear small in magnitude, they actually correspond to a practically relevant difference of one less dish of ice cream daily or a switch from regular to skim milk for a given student. Students from intervention schools also tended to consume less sodium than did students in the control group. While the intervention group advantage with respect to physical activity behavior narrowed over time, the intervention group continued to average more minutes of daily vigorous activity. The narrowest difference was among 8th graders, with intervention group students averaging 30.2 minutes per day, compared with just 22.1 minutes among students in the control group. (Note: There were no significant program effects on smoking; the smoking component of the program was purely classroom-based.) These findings suggest that a program that combines health education with behavioral components and school environmental modifications can improve physical activity and nutrition-related behaviors over three years after the end of the intervention. While the dissipating effects on physical activity behavior suggest that continued health promotion during junior and senior high school is warranted, further research is needed to identify the most effective programs to target these older adolescents (Nader, et al., 1999).

Indeed, to date, published program evaluations that focus on older adolescents have shown some promising results in the short term but generally have not been assessed for maintenance of impact (e.g., Fardy, et al., 1996; Killen, et al., 1989). For example, in the Stanford Adolescent Heart Health Program, four northern California high schools were randomized to intervention or control (Killen, et al., 1989). The 1,130 students with data at baseline and follow-up were 69% white, 2% black, 13.1% Asian, 6.4% Latino, and 9.6% other. In the intervention schools, 10th grade students, ages 14 to 16 years, received 20, 50-minute classroom sessions that covered physical activity, nutrition, smoking, and stress. The curriculum emphasized information on the immediate consequences as well as the long-term benefits of healthy behaviors, trained students in self-regulatory skills and problem solving, and incorporated development of an action plan designed to reach an individually chosen behavior change goal. By two months after the intervention, 30.2% of students in the treatment group who had not been exercising regularly at baseline had become regular exercisers, compared with 20.0% in the control group. The program was also associated with improvements in heart rate. Adolescent boys and girls in the treatment group showed a decrease in average heart rate of 2.3 and 4.1 beats per minute, respectively, while the average heart rate among all controls increased very slightly. Finally, students in the treatment group were also more likely than were students in the control group to report that they would select healthy foods for snacks. At least one nutrition-focused program supports the notion that setting and pursuing a specific behavior change goal may be an effective tool in affecting nutrient intake among adolescents (White & Skinner, 1988).

Beyond School-Based Programs

Although most of the programs to promote physical activity and nutrition among adolescents have been school-based, health behaviors outside of school are also critically important. Adolescents eat many meals and snacks outside of school, and they get most of their quantity of and variety in physical activity outside of school PE classes (Ross, et al., 1985). Moreover, it is critical that programs equip adolescents to carry their healthy behavior changes into adulthood, after leaving the structured environment of school programs (Ross, et al., 1985; Sallis, et al., 1992). However, our current knowledge about family-based and community-based programs is extremely thin. Some of the CATCH intervention schools included a very minimal family component, which appeared to enhance knowledge and attitudes related to physical activity and nutrition, but did not enhance the program impact on behaviors (Leupker, et al., 1996; Nader, et al., 1996). One family-based obesity reduction program evaluated the effect of targeting treatment, which focused on diet, exercise, and behavior management, to parents along with their children, as opposed to targeting the children alone. Among 55 primarily white families, additional targeting of treatment to the parents was associated with lesser weight gain and lower obesity among the children, with sustained effects through adolescence into young adulthood (Epstein, Valoski, Wing, & McCurley, 1990). Further research should evaluate the effects of family involvement in physical activity and nutrition promotion programs for adolescents as a whole and for high-risk groups, including adolescents who are overweight.

At the community level, the Minnesota Heart Health Program / Class of 1989 Study was a long-term school-based program, nested in a larger community-based intervention that was not targeted specifically to adolescents (Kelder, Perry, & Klepp, 1993). The main school-based components of the program were implemented in the 8th grade, with a second intervention in the 10th grade and follow-up through the senior year. The program content stressed physical activity knowledge, peer leader role modeling, peer support, positive reinforcement, and, in the 10th grade, healthy eating. The intervention had significant effects, especially among adolescent girls, on weekly hours of exercise—notably, outside of school. However, the experimental design did not allow for an evaluation of whether the broader community-intervention context added any additional program impact on adolescent health behavior, over and above that of the school-based program alone.

Summary of Programs to Promote Physical Activity and Good Nutrition

In summary, some multi-component, school-based programs designed to promote cardiovascular health through school environmental changes, behavioral approaches, and education have shown promising results. The Child and Adolescent Trial for Cardiovascular Health (CATCH), for example, was a school-based program that showed long-term positive effects on physical activity and nutrition. The CATCH evaluation involved a very large-scale randomized trial and indicates that multi-component, school-based programs modeled on CATCH are likely to meet with success.

Clearly, however, more research is needed to identify effective physical activity and nutrition promotion programs for adolescents. There is a particular need for evaluation of programs, beyond school-based programs, that are family- and/or community-based. Furthermore, as with smoking prevention, the maintenance of any changes in physical activity and dietary behaviors is critical and deserving of further research. Some long-term programs, like CATCH, have shown some success in maintenance of change over several years. However, the dissipating impact of CATCH over the long-term, and the much faster dissolution of impact observed in many other programs (e.g., Coates, et al., 1985), illustrate the need for further investment in maintenance of physical activity and dietary behavior change.

Sleep

Importance

Although researchers do not fully understand the functions of sleep, it is clear that sleep is a vital necessity. Insufficient sleep leads to drowsiness, which has a variety of important consequences for daily activities. Sleep deprivation is associated with performance lapses and slowed reaction times, as well as a phenomenon called microsleeps—brief mental lapses associated with momentary, unpredictable periods of sleep (Dahl, 1999; Pack, et al., 1995). One of the most serious risks associated with sleep deprivation and microsleeps is an increased risk of motor vehicle accidents. Motor vehicle accidents that are attributed to the driver having fallen asleep, in the absence of intoxication, are similar in severity to crashes attributed to drunk driving (Pack, et al., 1995). According to an analysis of data on non-drunk-driving, fall-asleep crashes in North Carolina, a striking 55% of fall-asleep crashes occurred among drivers ages 25 years or younger (Pack, et al., 1995). These same data suggest that the incidence of these motor vehicle accidents increases from initial licensure at age 16 to a peak at age 20.

Other consequences of insufficient sleep are important, too. Adolescents who get less sleep are more likely to arrive late to class because of oversleeping, and they tend to be tired during the school day (Wolfson & Carskadon, 1998). Moreover, sleepiness appears to lead to a difficulty in initiating and persisting in working toward goals, as well as a diminished ability to perform complex tasks (Dahl, 1999). For these reasons, researchers have suggested that excessive sleepiness may impinge on an adolescent's school performance. Indeed, shorter and more irregular sleep has been associated cross-sectionally with lower grades (Wolfson & Carskadon, 1998), although the research to date has yet to confirm that sleep deprivation precedes and causes poorer school outcomes.

Insufficient sleep also has been associated with behavioral and emotional problems, including a decreased ability to control mood and behavior (Dahl, 1999), increased externalizing problems (Wolfson, et al., 1995), and heightened negative affective responses (Leotta, Carskadon, Acebo, Seifer, & Quinn, 1997; Wolfson & Carskadon, 1998). However, this relationship is likely bi-directional—such that sleep deprivation contributes to behavioral and emotional problems, and emotional and behavioral problems interfere with sleep (Dahl, 1999). The *extent* to which sleep deprivation contributes to behavioral and emotional problems is yet to be elucidated in the research literature (Dahl, 1999).

Overall, the literature on the consequences of insufficient sleep in adolescence is still in its infancy. Much of the research on the effects of sleep loss in adolescence has been cross-sectional and/or based on extremely small samples, and there is a dearth of information on any long-term consequences of sleep deprivation (Dahl, 1999). However, the known short-term consequences of excessive sleepiness are sufficient to justify concern and research attention, particularly since many adolescents are not getting enough sleep. Indeed, one prominent researcher in the field (Carskadon, 1990) has suggested that adolescent sleep deprivation has not received the attention it deserves, in part because sleepiness is so common among adolescents that it practically has become a norm.

Prevalence and Trends

While the national data on adolescent sleep and sleepiness are limited, some national information is available. Data from the 1995 National Longitudinal Study of Adolescent Health (Add Health), suggest that just over one-quarter of adolescents ages 12 to 17 years report that they do not get enough sleep (DHHS, 1999). [Some local surveys show a much higher prevalence of perceived insufficient sleep (Wolfson & Carskadon, 1998).] Nationally, adolescent females are somewhat more likely than are their male peers to report that their sleep is inadequate, and adolescents who live in a single-father family are more likely than are adolescents living in a two-parent or single-mother family to report not getting enough sleep (DHHS, 1999).

There are also noteworthy trends according to age. If anything, older adolescents appear to need more sleep than younger adolescents (Carskadon, 1990). However, adolescents tend to get less sleep as they get older. According to the Add Health study, while 83.3% of students in grades 7 and 8 report getting enough sleep, just 72.5% of 9th and 10th graders and 66.5% of 11th and 12th graders feel that their sleep is sufficient (DHHS, 1999). Indeed, smaller-scale studies have consistently shown that, as adolescents get older, they tend to get less sleep, have later bedtimes, and have sleep schedules that vary more widely from weekday to weekend nights (Allen, 1991; Carskadon, 1990; Dahl, 1998; Wolfson & Carskadon, 1998). Knowledge to date suggests that this variation in weekday to weekend schedules is likely to leave adolescents experiencing something like jet lag, and having trouble readjusting to an early schedule when the week resumes (Dahl, 1998).

Antecedents and Correlates of Sleep Habits

Despite the likely impact of sleep deprivation on adolescents' lives, the existing research on predictors of adolescent sleep patterns is thin. As is true of research on the consequences of sleep patterns for adolescents, almost all of the studies regarding predictors of sleep behaviors in adolescents have been cross-sectional and/or based on only a handful of subjects—as few as 15 in some studies.

Individual Antecedents and Correlates

However, there is at least one large, longitudinal study that evaluated predictors of sleep problems among adolescents (Patten, Choi, Gillin, & Pierce, 2000)—though it should be noted that this study includes some subjects who were no longer adolescents at follow-up. In this study, Patten and colleagues analyzed data from the Teenage Attitudes and Practices Survey (TAPS). The TAPS participants included 3,921 girls and 4,039 boys who had participated in the 1989 National Health Interview Survey and completed the TAPS survey both at baseline in 1989 and at follow-up four years later. Participants were 46% female and 75% white, 15% black, 8% Hispanic, and 3% Asian or other. The age range of the participants was 12-18 years at baseline and 15-22 years at follow-up. At baseline, 38.8% of participants reported sleep problems, and 14.4% reported frequent sleep problems, defined as "often" having "had trouble going to sleep or staying asleep" during the previous 12 months. Among those participants who did not report sleep problems at baseline, boys were 30% less likely than were girls to develop sleep problems by follow-up four years later, and 40% less likely to develop frequent sleep problems. Those who were identified as being rebellious at baseline, based on their enjoyment of risky or dangerous behaviors and involvement in physical fights, were about 30% more likely to develop frequent sleep problems over the subsequent four years than were their less rebellious peers. Depressive symptoms also predicted the development of sleep problems, as adolescents who reported "notable" depressive symptoms at baseline were about 50% more likely to develop sleep problems and frequent sleep problems than those without such symptoms. Finally, smoking at baseline predicted later sleep problems, such that those who smoked the most were most likely—and those who did not smoke at all were least likely—to develop sleep problems and frequent sleep problems over the four-year period. Notably, among those who did report sleep problems at baseline, girls were more likely than were boys, and Asian adolescents were more likely than were adolescents of other racial backgrounds, to report continued sleep problems four years later. Baseline smoking also predicted continued sleep problems, while those who stopped smoking during the four-year period experienced a reduced risk of continued sleep problems by follow-up in 1993. Continued sleep problems were also more common among adolescents who had depressive symptoms at baseline, although this relationship is complicated by the fact that sleep difficulties can be a symptom of depression.

Cross-sectional studies have identified other potential determinants of adolescent sleep patterns. Carskadon and colleagues (Carskadon, Vieira, & Acebo, 1993) surveyed a non-random sample of sixth graders that included 183 boys and 275 girls, primarily Caucasian and from small- to medium-sized towns or small cities. Although these students were in the same grade in school, those who were further along in pubertal development had a later weekday bedtime and were more likely to show characteristics indicative of 'night persons' rather than those of 'morning persons', when compared with their peers in earlier stages of puberty. This suggests that pubertal development may affect adolescent sleep behavior.

A cross-sectional survey of 1,528 female and 1,566 male public high school students in suburban and rural Rhode Island suggests that sleep behaviors may also be related to employment (Carskadon, Mancuso, & Rosekind, 1989). (The ethnic composition of the participants was not detailed in the study report.) In this study, adolescents who worked 20 or more hours per week (high-work students) tended to sleep less and to get to bed later on both weekdays and weekends than did adolescents who worked less than 20 hours or not at all (Carskadon, et al., 1989). The high-work students were also more likely to report being late to school because of oversleeping, and more often fell asleep during the day at school or while doing homework. High-work students also tended to consume more coffee and tea.

Also at the individual level, factors including emotional arousal, stress, pain, and the use of stimulants, such as coffee and tobacco, are thought to interfere with sleep among people of all ages, including adolescents (Dahl, 1998). Specific sleep disorders like narcolepsy, although not terribly common among adolescents, account for a small fraction of adolescent sleep difficulties (Dahl, 1998).

Antecedents and Correlates Beyond the Individual Level

As sleep generally occurs in a family home, family factors are likely to influence sleep habits. As noted above, adolescents living in single-father families are more likely than are adolescents living in other family structures to report insufficient sleep (DHHS, 1999). Moreover, as children age to adolescence, parents appear to become less involved with setting bedtimes but more involved in getting their child to wake up in the morning (Carskadon, 1990). These findings indicate that longitudinal studies should evaluate elements of the family context as potentially important determinants of adolescent sleep behavior.

In general, researchers tend to consider adolescent sleep deprivation the result of a clash between an increased need for sleep and the variety of time constraints imposed by employment, activities, homework, social involvement, and early school start times (Dahl, 1998; Wolfson & Carskadon, 1998). Thus, peers and the school and community environments may influence adolescent sleep patterns. Potential peer effects have not received research attention.

There has been much recent interest in the proposed relationship between school start times and adolescent sleepiness. Although adolescents tend to have a sleep 'phase-delay', such that they tend toward later bedtimes and rising times, school start times become earlier and earlier as students progress from elementary, to junior high, to high school. Preliminary cross-sectional studies suggest that high school students attending schools with an earlier start time tend to get less sleep than those attending high schools with a later start time (Allen, 1991), and that total sleep tends to decrease as students transition from junior high to an earlier-starting high school (Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998).

The Minneapolis public school system instituted a change in school start times beginning with the 1997-1998 school year. High school start times were moved from 7:15 to 8:40 a.m. and middle school start times were shifted from 7:40 to 9:40. Individual elementary school start times were set at 7:40, 8:40, or 9:40. Kubow, Wahlstrom, and Bemis (1999) have reported the preliminary results of teacher surveys and teacher and student focus groups regarding the perceived effects of the change in school start time. The reactions were mixed. More than half (57%) of the high school teachers reported that students were more alert during morning classes than they had been with the earlier start time. There were concerns among urban students and their teachers, however, that the new schedule interfered with students' available time for homework and studying as well as with their work hours and income, social opportunities, and extracurricular activities. Teachers also noted safety considerations associated with the later school end-time. Interestingly, suburban high school students and teachers tended to have a more positive take on the later school start time. The study authors propose that the later school start-time may influence different school populations in different ways, due to disparities in the availability of private transportation and/or other factors. Although not at all definitive, these findings suggest that changing school start-times in response to concerns about adolescent sleepiness is likely to have both positive and negative consequences.

Summary of Research on Adolescent Sleep Behaviors

Overall, the most urgent need today is for further research to identify the antecedents of insufficient sleep and excessive sleepiness among adolescents, and to make use of the resulting findings to inform programs designed to improve adolescent sleep habits. Researchers have proposed various program strategies, including educational efforts targeting children, parents, educators, and health care professionals, altered school start times, and behavioral regulation of sleep patterns (National Institutes of Health [NIH], 1997). The limited current literature further suggests that targeting smoking, depression, rebelliousness, parental involvement in setting bedtimes, and demands on adolescents' time—including employment, activities, homework, and social involvement—may also be useful program approaches. To date, however, no program evaluations have been published in the mainstream literature.

Dental Health Behaviors

Importance

Dental afflictions, including dental caries, tooth loss, and periodontal diseases, are associated with a wide array of health behaviors. The most obvious and specific oral hygiene behaviors include tooth brushing, flossing, fluoride use, and seeking care and preventive care at the dentist. Other health behaviors that affect dental health are nutrition—including sugar intake (Szpunar, et al., 1995), calcium intake (DHHS, 2000b), and episodes of malnutrition (Alvarez, 1995)—and the use of smokeless tobacco (DHHS, 2000b; Marcus, Winn, & Brown, 1996) and cigarettes (Krall, Dawson-Hughes, & Garcia, 1996; Marcus, et al., 1996). In this section, we will focus on the health behaviors specific to oral hygiene, while acknowledging the key contributions to dental health of other health behaviors that are covered in separate sections of this paper.

The importance of dental health is clear, as dental caries is one of the most common diseases among adolescents and children in the United States today. Among 5- to 17-year-olds, dental caries are five times as common as asthma, and seven times as common as hay fever (DHHS, 2000b). According to national surveys, more than three-quarters of 17-year-olds have at least one cavity or filling (DHHS, 2000b) and about one in every five adolescents has at least one untreated caries lesion or active tooth infection (MacKay, Figerhut, & Duran, 2000). The burden of this disease is not equitably distributed. Adolescents living in families with incomes near or below the federal poverty level (FPL) are three times more likely to have untreated caries than are adolescents living in families with incomes at least twice the FPL (MacKay, et al., 2000; see also Vargas, Crall, & Schneider, 1998). Moreover, African-American and Mexican adolescents are about twice as likely to have untreated caries as are their non-Hispanic white peers (MacKay, et al., 2000; Vargas, et al., 1998). Untreated dental caries have a number of consequences, including pain, which can interfere with diet, nutrition, sleep, learning, and other daily functions (DHHS, 2000b), and an increased risk of periodontal diseases (Albandar, Buischi, & Axellson, 1995). Untreated caries are also associated with tooth loss; by age 17, more than 7% of adolescents in the U.S. have lost at least one permanent tooth to caries (DHHS, 2000b).

Dental hygiene and professional care—along with good nutrition and avoidance of tobacco use—are associated with a reduced risk of dental caries and their consequences. Tooth brushing and flossing help to prevent periodontal disease by disrupting and removing accumulating plaque, and tooth brushing with a fluoride toothpaste delivers a small dose of fluoride to the teeth (DHHS, 2000b). Fluoride has the ability to slow or even reverse the development of caries lesions, and its introduction into much of the public water supply has contributed heavily to the overall drop in dental caries prevalence over the past few decades (DHHS, 2000b). For persons living in areas with non-fluoridated water supplies, fluoride supplements and fluoride mouthrinses can provide alternative sources of fluoride, contingent on individual use.

Professionally applied sealants, which are plastic films that coat and serve as a protective barrier for the chewing surfaces of the teeth, help to prevent cavities in the deep pits and fissures of teeth, where tooth brushing and fluoride are less effective (DHHS, 2000b). According to the National Health and Nutrition Examination Survey III (NHANES III), a nationally representative survey of the U.S. population in 1988-1994, 27.3% of 5- to 17-year-olds without sealants had untreated tooth decay, compared with just 11.1% of those with sealants (Nowjack-Raymer, Drury, & Selwitz, 1996). Interestingly, results from this survey further suggest that the socioeconomic disparity in untreated caries is striking among children and adolescents without sealants, but nearly nonexistent among children and adolescents with sealants (Nowjack-Raymer, et al., 1996). However, children and adolescents of low socioeconomic status are much less likely to have sealants than are their higher-income peers (Stack, Selwitz, & Drury, 1996). Finally, regular dental visits have been associated with fewer untreated caries, at least among younger children (Ismail & Sohn, 2001).

Prevalence and Trends

The national data regarding the prevalence of healthy dental behaviors in adolescents are limited. However, the Health Behavior in School-Aged Children (HBSC) Study, an international survey of health behaviors among school children ages 11, 13, and 15 years, provides one source of national data on tooth brushing. According to the U.S. component of the HBSC, across the three age groups, about 75 to 80 percent of girls brush their teeth more than once per day, compared with about 65 percent of boys of these ages (Vereecken & Maes, 2000). So, while most children are brushing their teeth fairly frequently and regularly, girls are more likely to do so than are boys, and this gender difference appears to increase with age (Vereecken & Maes, 2000). Another, less recent study (Chen & Rubinson, 1982) indicates that flossing is a much less common dental health behavior. In this national survey of white families, 25.5% of children and adolescents flossed at least weekly, and just 6.4% flossed daily. As for professional preventive care, in 1997, about 64% of poor adolescents and 80% of near-poor and non-poor adolescents, nationally, reported having visited the dentist in the past year (MacKay, et al., 2000). During 1988-1994, sealants were in place for about one-quarter of children and adolescents in families with an annual income of $30,000 dollars or more and about 9 percent of children and adolescents in families with an annual income of $15,000 or less (Stack, et al., 1996).

Notwithstanding the importance of dental health behaviors, the research literature regarding antecedents of dental health behaviors among adolescents is very sparse. The available research is primarily cross-sectional, performed outside of the U.S., and/or focused on dental caries as the outcome of interest, rather than on the prediction, promotion, and maintenance of healthy dental behavior patterns per se. The scarcity of publications regarding dental health behaviors among adolescents may seem surprising given specific research investments in dental and oral health, as evidenced in part by the existence of a National Institutes of Health institute, the National Institute of Dental and Craniofacial Research, dedicated to research on oral health. However, dental health behaviors among adolescents have not tended to be a particular research focus of these endeavors, which have instead focused on many of the wide variety of topics that combine to make up the oral health field. These research topics span such outcomes as the basic science behind and professional treatment and prevention of cavities and periodontal diseases; birth defects, such as cleft lip and palate; and oral cancers. These, too, are vitally important topics for research; however, adolescent dental health behaviors arguably deserve additional research attention.

Antecedents and Correlates of Dental Health Behaviors

Toothbrushing and Flossing

There is virtually no research regarding the antecedents of personal dental hygiene among adolescents. One longitudinal study (Astrom, 1998) followed 597 Norwegian high school students, 49% of whom were boys, from 10th to 12th grade. This study was designed to evaluate predictors of a composite measure of adolescent dental hygiene: the sum of an adolescent's use of dental floss, use of toothpicks, tooth brushing, and intake of non-sugared mineral water. Among this group of Norwegian students, maternal dental hygiene performance at baseline predicted adolescent dental hygiene performance two years later, after controlling for baseline adolescent dental hygiene. Moreover, girls consistently outperformed boys on the sum of these behaviors. It is likely that other individual-level factors and family influences affect adolescent dental health behaviors, and that peer influences and the broader environmental context may be important, too, but the research literature has yet to address these topics.

Utilization of Professional Care

Dental anxiety among adolescents has shown cross-sectional associations with utilization of professional dental care in one Scottish (Bedi, Sutcliffe, Donnan, Barret, & McConnachie, 1992) and one Singaporean (Milgrom, Vignehsa, & Weinstein, 1992) study. Among 1,103 Scottish high school students, with an even gender split and an average age of 14 years, those with high dental anxiety were more likely than were their less dentally-anxious peers to defer, cancel, or not show up for dental appointments (Bedi, et al., 1992). They were also less likely to have dental sealants. These factors were further associated with clinical outcomes, as adolescents with high dental anxiety were 62% more likely than were their peers to have at least one missing tooth due to caries. Since these studies were cross-sectional, the direction of causality has not been established; however, it is plausible that the relationship is cyclical. Dental anxiety may lead to avoidance of preventive service, which in turn may lead to dental problems that require more invasive professional treatment, which in turn may further exacerbate dental fears (Milgrom, et al., 1992). This issue deserves further consideration in the research literature.

Socioeconomic and insurance status may also affect utilization of preventive care. As noted above, poor adolescents are less likely than are near-poor and non-poor adolescents to visit the dentist (Chen, 1986; MacKay, et al., 2000) and to have dental sealants in place (Stack, et al., 1996). Moreover, low-income adolescents, especially those living near poverty, are less likely to have dental insurance (51%) than are either their higher-income peers (65%) or those living below the poverty level (60%; MacKay, et al., 2000). Children and adolescents without dental insurance are three times more likely to have unmet dental needs than are children with insurance, public or private (DHHS, 2000b). However, it is important to note that, according to one recent study of much younger children (Ismail & Sohn, 2001), access alone does not appear to account for the socioeconomic disparity in dental disease burden. This study surveyed first-grade children in Nova Scotia, Canada, where all children are covered by one insurance program that provides basic preventive, restorative, and surgical services (Ismail & Sohn, 2001). Despite this universal 'access' to professional dental care, children whose parents had low educational attainment had more cavitated teeth than did children whose parents had completed higher levels of education. This suggests that other factors—perhaps dental hygiene behaviors and/or dietary composition—also shape the socioeconomic disparities in dental health. Future research should attempt to elucidate the reasons behind this socioeconomic disparity, focusing on adolescents as well as on younger children.

Other antecedents of utilization of professional dental care likely include additional individual and environmental factors, as well as parental and peer influences. Individual attitudes and beliefs about dental care, ease of access to transportation, and a parent's ability to take time off from work are examples of potentially important predictors of utilization that deserve further research interest.

Programs to Promote Healthy Dental Behaviors

Programs designed to promote dental health have focused primarily on bringing preventive services—including fluoride supplement or mouth rinse sessions and professional application of dental sealants—to schools (e.g., Morgan, Crowley, & Wright, 1998). The cost-effectiveness of such programs is unclear (Klein, et al., 1985; Morgan, et al., 1998). Few programs have been implemented to promote self-sufficient dental hygiene behaviors, including brushing and flossing. Those that have been implemented have not necessarily been successful in changing dental health behaviors (e.g., Klein, et al., 1985; Russell, Horowitz, & Frazier, 1989), and those that have been touted as successful have not been evaluated in a rigorous manner with regard to quality analysis, generalizability, and assessment of non-immediate effects.

For example, Walsh (1985) evaluated a school-based program that was implemented among 639 7th and 8th graders in ten San Francisco public middle schools. The study population was 22% Spanish surname, 18% white, 23% black, and 37% Asian, and about evenly split between boys and girls. Dental hygiene students led four, hour-long sessions on dental health and hygiene, with supervised practice in brushing and flossing. At post-test, few differences in behavior were noted, and, although the study author suggested that girls in the experimental group had an increase in the frequency of tooth brushing and flossing, there were problems with the study analysis. Moreover, there was no elapsed time between the end of the program and its evaluation.

A second program was implemented among about 200 6th graders attending a private school in Sao Paulo, Brazil (Axelsson, Buischi, Barbosa, Karlsson, & Prado, 1994; Buischi, Axelsson, Oliveira, Mayer, & Gjermo, 1994). The most intensive program condition consisted of an extensive dental hygiene training program, including educational and behavioral components. An evaluation suggests that the program was associated with greater use of plaque disclosing solution, somewhat greater use of dental floss, and fewer new cavities (Axellson, et al., 1994; Buischi, et al., 1994); however, the analysis did not account for differences between the experimental and control groups at the start of the study. Furthermore, it is unclear whether these results would be applicable to other populations. These studies suggest that combined educational and behavioral approaches may be effective, but, to date, there are no sufficiently compelling findings to fully support this claim. Moreover, the cost-effectiveness of such intensive programs is uncertain. As with other health behaviors, maintenance of dental health behavior change is an essential consideration (Ivanovic & Lekic, 1996). Future studies should include rigorous evaluation of programs designed to promote lasting, positive, dental health behaviors and to alleviate the potential barriers to utilization of professional care.

Summary of Research on Adolescent Dental Health Behaviors

In summary, there is a wide gap in the published literature concerning the antecedents of and programs to promote personal dental health behaviors, such as toothbrushing and flossing, among adolescents. The limited available research suggests that adolescent girls may have better dental health behaviors than do adolescent boys and that dental health behaviors among mothers may influence those of their adolescent children. Potentially important antecedents of use of professional care include dental anxiety and socioeconomic and insurance status.

The current literature regarding programs to promote self-sufficient dental health behaviors among adolescents is quite thin and suffers from methodological limitations. Existing program evaluations suggest that programs that include behavioral components, such as training in personal dental hygiene and in self-evaluation of dental health and hygiene, along with the provision of information regarding dental health and hygiene, may be effective. Programs to bring fluoride to communities, particularly via fluoridation of the water supply, are among the successful efforts to date to prevent dental caries. An increased focus on personal dental behaviors, also important to dental caries risk, is warranted.

Common Themes

Although the current research on and knowledge regarding the various health behaviors discussed here are in different stages of development, in general, we know more about why healthy behaviors are important than about what predicts or determines these behaviors—or what can be done to promote them. Perhaps the most common thread that ties these behaviors together is their complexity; each is likely a product of multiple influences on multiple levels. Individual factors, peer and family effects, and the broader community and environmental context are likely interacting to shape the health behaviors of adolescents.

There are some other continuities as well. Health behaviors tend to covary in adolescents (Lytle & Roski, 1997; Pate, Health, Dowda, & Trost, 1996), which suggests that there are likely to be common predictors of a generally healthy lifestyle. Of note, adolescents in families with lower incomes tend to bear a disproportionate share of the burden of unhealthy behaviors. In general, these adolescents are more likely than are their peers to display specific health-compromising behaviors and to practice multiple unhealthy behaviors (Lowry, et al., 1996).

Common themes have arisen across the evaluations of existing programs designed to promote healthy behavior change. On the whole, programs that simply convey health information are usually not sufficient to effect behavior change. Programs that target psychosocial determinants of health behaviors and those that include a behavioral component tend to meet with more success. Across health behaviors, maintenance of improvements in health behaviors remains a critical challenge. Booster sessions, and the utilization of settings for behavior promotion that can be extended or translated into future life stages, may help.

Preventing Injury, Promoting a Safe Lifestyle

Importance, Prevalence and Trends

The importance of injury among adolescents lies, in large part, in the contribution of injury to adolescent mortality. It should be noted that, as to be expected, overall mortality rates among adolescents are relatively low when compared with older age groups. However, injuries, many of which are likely preventable, account for the vast majority of adolescent deaths, outweighing all natural causes combined. Nationally, in 1998, injury deaths comprised more than half of all deaths among 10- to 14-year-olds, and, staggeringly, nearly four of every five deaths among adolescents ages 15 to 19 years.[8] Fatal injuries, in causing early and often preventable death, have an immeasurable impact.

Nonfatal injuries are also of consequence. Nationally representative data from the Child Health Supplement to the 1988 National Health Interview Survey suggest that, over the course of a single year, about one-quarter of 10- to 13-year-olds and more than one-third of 14- to 17-year-olds experience a nonfatal injury (Scheidt, et al., 1995). Also over the course of one year, about seven percent of 10- to 13-year-olds and 11.5 percent of 14- to 17-year-olds suffer a serious injury that requires hospitalization, missed school, or stitches or other surgery. As these statistics indicate, nonfatal injuries vary in severity; and the extent and duration of the influence of a nonfatal injury on an adolescent's life tends to reflect that severity. Minor injuries might require only a brief recovery period, with minimal disruption of daily life and activities. At the other extreme, the most severe nonfatal injuries can result in life-long disability, with sizable associated personal, social, and financial costs.

In the research literature, injuries are typically grouped into one of two categories. "Unintentional" injuries are those that result from seemingly accidental causes, including many motor vehicle crashes, bicycle crashes, sports mishaps, work hazards, burns and falls. Researchers in the field increasingly prefer to use the term "unintentional" in place of "accidental" (and "crash" in place of "accident") in order to emphasize that these injuries (and incidents) are believed to be, in large part, both predictable and preventable. "Intentional" injuries form the other broad category of injury type, and include injuries caused by acts of violence, encompassing both self- and other-inflicted violent acts. However, it should be noted that the intention behind an injury-causing event is not always known or clear, and intention may not always segregate faithfully according to the definitions of unintentional and intentional injury. The discussion of injury to follow will focus on unintentional injuries. Intentional injuries are also critically important, as homicide and suicide are, respectively, the second and third leading causes of death among youth ages 15 to 24 years (Murphy, 2000). [For a discussion of intentional injuries, please see the Knight report on mental health and disorders (Zaff & Calkins, 2001) for information on suicide and the recent Surgeon General's report on violence among youth (DHHS, 2001) for information on violence.]

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[8] Author's calculation based on national death count data obtained via CDC WONDER, Retrieved on January 23, 2001 from the World Wide Web: http://wonder.cdc.gov/

The sources and contexts of unintentional injury among adolescents and other age groups are numerous and cannot be covered in full here. However, the following discussion of the overall prevalence and trends of unintentional injury, with selected examples of specific injury types, should provide a general picture of the state of adolescent injury today.

Nationally, unintentional injuries account for the majority of adolescent injury deaths, including more than half of all injury deaths among adolescent males and three-quarters of all injury deaths among adolescent females (MacKay, et al., 2000). Motor vehicle-related injuries are the most common cause of unintentional and total injury deaths among adolescents (MacKay, et al., 2000).

Notably, the burden of injuries is not shared equitably across demographic groups. Injuries and injury deaths are more common among adolescent males than among their female peers (Scheidt, et al., 1995; see also footnote[8]). For example, the rate of death due to motor vehicle-related injuries is higher among adolescent males than among adolescent females and this gender gap widens as adolescents age (MacKay, et al., 2000).

Unintentional injury death rates in general, and motor vehicle-related death rates in particular, rise dramatically with age among adolescents, with especially striking jumps between the ages of 15 and 16 years (MacKay, et al., 2000). Nationally, death rates due to unintentional injury increase about four-fold between the ages of 12 and 17 years (based on data from MacKay, et al., 2000). Nonfatal injuries and injury-related emergency department visits, including those that are motor vehicle-related, also increase with age throughout adolescence (MacKay, et al., 2000; Scheidt, et al., 1995).

Ethnic differences exist, too. National data indicate that American Indian and Alaska Native adolescents suffer from the highest rates of motor vehicle-related deaths, while adolescents of Asian or Pacific Islander descent have the lowest rates (MacKay, et al., 2000). Non-Hispanic white adolescents are more likely to die from motor vehicle-related injuries than are their non-Hispanic black and Hispanic peers. These disparities may reflect differences in exposure to motor vehicle situations and/or associated risk behaviors.

Over time, between 1975 and 1992, the absolute number of motor vehicle-related deaths among 16- to 19-year-olds in the U.S. decreased markedly, coinciding with a drop in the population size of this age group over the course of the 1980s (Insurance Institute for Highway Safety [IIHS], 2001). This trend has since reversed, as the population of adolescents of driving age has grown. However, the absolute number of adolescents who died in motor vehicle crashes in 1999 was still well below the 1975 levels (IIHS, 2001).

In addition to motor vehicle-related injuries, other injury types are also important contributors to the burden of unintentional injury among adolescents. Recreational activities, for example, contribute heavily to adolescent injury. According to the 1999 YRBS, about 38% of high school students reported that they had incurred an injury, requiring treatment by a doctor or nurse, while engaging in physical activity at some point over the prior year (Kann, et al., 2000). These data further suggest that injuries associated with physical activity are more common among adolescent boys than among adolescent girls. Moreover, white students were more likely than were their black peers to report having had an injury while physically active.

Bicycle crashes are one important cause of recreational injury, and, in particular, of head injury during childhood and adolescence. Among children and adolescents ages 19 years or younger, an average of about 451,000 nonfatal bicycle injuries and 140,000 head injuries due to bicycling are treated in emergency departments in the United States each year (Sosin, Sacks, & Webb, 1996). Rates of bicycle-related head injuries are greatest among children ages 5 to 9 years, but remain quite high through early adolescence (Sosin, et al., 1996). In addition to bicycling, other recreational activities that contribute to injuries among adolescents include—but are not limited to—in-line skating, water activities, and other individual and group sports, such as basketball, football, and baseball (Burt & Overpeck, 2001).

Injuries at work also account for a sizable number of emergency department visits among adolescents. In 1992, for example, occupational injuries triggered about 64,000 emergency department visits among adolescents ages 14 to 17 years (Layne, Castillo, Stout, & Cutlip, 1994). Here, too, adolescent males show a higher rate of injury than do their female peers.

In summary, successful injury prevention will be critical to efforts to improve adolescent well being and to prevent numerous unnecessary early deaths in this age group. The vital importance of efforts to prevent adolescent injuries is reflected in several Healthy People 2010 objectives to reduce the occurrence of injuries and injury deaths and to promote safety habits among adolescents (DHHS, 2000a).

Antecedents of Adolescent Injury

This section will explore the antecedents of unintentional injury in general, as well as the antecedents of injuries specifically associated with motor vehicle crashes, bicycle accidents, and hazards at work. An evaluation of these specific injury occurrences will provide a richer picture of the factors associated with unintentional injury among adolescents, since only a handful of studies have assessed the predictors of adolescent unintentional injuries, of all types, as a group. It should be reiterated that injuries associated with motor vehicle crashes, bicycling, and work do not by any means encompass all types of unintentional injuries, which can occur in a tremendously wide variety of settings, such as in the home, on sports teams, and in the context of water activities. Additional important types of unintentional injury include sports injuries, burns, falls, and poisonings, among others. However, the specific examples included here should provide an in-depth picture of what the research literature shows with regard to three vitally important causes of unintentional injuries among adolescents, as well as with regard to unintentional injuries overall.

Antecedents of Unintentional Injuries as a Group

A few studies have investigated the factors associated with adolescent unintentional injuries as a whole. These studies have, in particular, highlighted several individual level antecedents of unintentional injuries.

Individual Antecedents and Correlates

One longitudinal study, designed to identify antecedents of serious injuries requiring treatment by a doctor or nurse, followed more than 600 adolescents, in rural eastern Maryland, from the 8th through the 10th grade (Alexander, Ensminger, Somerfield, Kim, & Johnson, 1992). The study cohort was 53% male and 37% black, and 64% of the participants lived in two-parent homes. In this cohort, adolescent males were at a higher risk of injury than were their female peers. This finding has been replicated across numerous studies.

Alexander and colleagues (1992) also found that various risky behaviors predicted later injury in their rural cohort. Participants who used alcohol or marijuana were more likely to report serious injury, as were those who generally exhibited a high risk-taking behavior pattern and those with school discipline problems. Indeed, substance use and general risk-taking behavior have been identified as antecedents of numerous specific injury types, as will be detailed in the following sections. Certain extracurricular activities were also associated with a greater risk of injury. Adolescents who played on sports teams and those who were employed were more likely than their peers to report later injury.

Other studies have also identified an increased risk of injury among adolescents who participate in physical activity. The Adolescent Injury Control Study followed 1,245 junior high students, from a metropolitan school district in Pittsburgh, over the course of four years (LaPorte & Dearwater, n.d.). The authors state that the participants represented a diversity of socioeconomic and ethnic backgrounds. Although the injuries resulting from sports and recreation were not generally acutely severe, sports and recreation accounted for a majority of physician-treated injuries among the adolescents in this cohort. Habitual physical activity and participation on team sports were each associated with an increased likelihood of injury. Based on this finding, the study authors suggest that physical activity should be considered a "double-edged sword"—with clear health benefits (as described in the physical activity and nutrition section of this chapter) but also clear risks in the context of injury.

Childhood aggression has also been associated with injury among adolescents. Cobb, Cairns, Miles, and Cairns (1995) followed 271 children from either the 4th or the 7th grade through ages 14 to 18 years. The participants were from one suburban-metropolitan area and one rural area, were 48% male, and were 23% African American and 76% Caucasian American. Aggressive behavior, as reported by the participants' teachers in the 4th or 7th grade, predicted overall injury occurrence over the course of the study. Childhood aggression was also associated with the risk of "close-calls", or cases in which a potentially injury-producing incident almost occurred. This result may be related to the finding that school discipline problems predicted injury among the rural participants in the study by Alexander and colleagues (1992), described above.

Antecedents and Correlates Beyond the Individual Level

A few studies have identified antecedents of unintentional injuries, as a group, at broader environmental levels. Studies regarding more specific injury outcomes, to be discussed below, will fill some of the holes in the present discussion of antecedents beyond those at the individual level.

The available findings regarding socioeconomic status and injury risk are mixed. For example, in the longitudinal Adolescent Injury Control Study, described above, there was no association between socioeconomic status, measured in a variety of ways, and either overall injury risk or the distribution of injury type (Anderson, et al., 1994). In another recent study of 4,710 Scottish adolescents ages 11, 13, and 15 years, socioeconomic status was similarly unassociated with injury risk, but was associated cross-sectionally with injury type and setting (Williams, Corrie, Wright, Elton, & Beattie, 1996). For instance, lower socioeconomic status was associated with a greater likelihood of bicycle and pedestrian injuries, while higher socioeconomic status was associated with a greater likelihood of sport and passenger car injuries. Further study should evaluate whether this difference is due to study design and measurement, to geographic location, or to other factors.

In a just released study, Kane, Mickalide, and Paul (2001) investigated the relationship between season and unintentional injury among children and young adolescents. Using nationally representative data on mortality due to drowning, falls, pedestrian injury, bicycle injury, and motor vehicle crashes among children ages 14 and younger, Kane and colleagues found that the largest proportion of unintentional injury deaths took place over the summer, between May and August. This pattern was most evident among older children and young adolescents between the ages of 10 and 14. In this group, 45% of unintentional injury deaths occurred during the summer. Nonfatal injuries appear to follow the same seasonal pattern, which is generally less pronounced in regions with milder weather and less distinct seasons. It would be interesting to assess whether unintentional injury among older adolescents shows a parallel seasonal variation, and to investigate the specific reasons for the seasonality of unintentional injury occurrence. Possible explanations include greater recreational activity, increased driving for summer vacations, and decreased supervision and structure during non-school months (Kane, et al., 2001).

Summary of Antecedents and Correlates of Unintentional Injuries as a Group

In summary, the available literature has identified several individual-level antecedents of unintentional injury risk among adolescents. Adolescents who use alcohol or marijuana, those who displayed aggressive traits as a child, and those who exhibit a general inclination to risk-taking behavior are more likely than are their peers to experience an injury. Employment and participation in sports are also risk factors for injury during adolescence. The literature regarding antecedents beyond the individual level is sparse; however, studies on the antecedents of specific injury types, described below, do begin to fill this gap.

Antecedents and Correlates of Motor Vehicle Injuries and Related Outcomes

The available literature regarding factors related to motor vehicle crashes, injuries, and related outcomes includes some longitudinal studies, but still is primarily based on cross-sectional designs. The following discussion of factors associated with motor vehicle crashes relies on longitudinal studies, where available, and on cross-sectional studies to supplement where there are gaps in the longitudinal literature.

Individual Antecedents and Correlates

Several risk and safety behaviors, including seatbelt use, reckless driving, and driving after drinking are associated with motor vehicle crashes (MVC) and injuries. There is a general agreement that donning a seatbelt reduces the risk of fatal and nonfatal injuries in the event of an MVC. The National Highway Traffic Safety Administration [NHTSA] has issued a report that combines information across various data sources to estimate the protective value of seatbelts (1984). According to these estimates, based on data regarding passengers in the front seat of a passenger vehicle, the use of a manual lap/shoulder belt approximately cuts in half the risk of fatality and of moderate to serious injury in the event of an MVC. Wearing a manual lap belt decreases the risk of fatality by about 35% and of moderate to serious injury by about 30%. However, a sizable fraction of adolescents are not benefiting from the protection of seatbelts. According to the 1999 YRBS, about one of every six high school students reports rarely or never wearing seatbelts when riding as a passenger in a car or truck (Kann, et al., 2000). High school boys are more likely than are high school girls to report rarely or never using seatbelts (20.8% vs. 11.9%).

A case-control study, based on a population of 16- to 19-year-olds in Gwinnett County, Georgia, suggests that risky driving behaviors are associated with an increased risk of being in an MVC (CDC, 1994b). This study compared the self-reported risky driving behaviors among a group of 64 adolescents who were involved as drivers in an injury-producing MVC, with those among a group of 224 comparison adolescents. The comparison group included adolescents who were between the ages of 16 and 19 years, were licensed drivers, were never involved in a police-reported crash, and were otherwise randomly selected from the enrollment files of the Gwinnett County public high school. Adolescents who had been involved as a driver in an injury-producing MVC were more likely than adolescents in the comparison group to report driving more than 20 miles per hour over the speed limit, passing a car in a no-passing zone, and taking driving risks to enhance driving pleasure. These findings suggest that reckless driving behaviors are associated with an increased risk of being in an injury-producing MVC. Data from the 1997 National Survey of Speeding and Other Unsafe Driving Actions, the first national survey of its kind, suggest that risky driving behaviors are quite common, especially among adolescent and young adult drivers. For example, 82% of 16-20 year-old drivers reported driving 10 miles per hour faster than most other vehicles at some point during the past year, while 44% drove through a red light, 39% cut in front of another car to make a turn, and 26% raced another driver (NHTSA, 1998).

It is well known that driving after drinking increases the risk of an MVC. Some researchers have estimated the extent to which various blood alcohol concentrations (BAC) increase this risk.

Zador, Krawchuk, and Voas (2000), for example, examined national data from the Fatal Accident Reporting System (FARS), which compiles information on almost all of the fatal MVCs on public roads in the U.S. The distribution of BAC of drivers involved in fatal single-vehicle crashes was compared with that of the general population of drivers, as determined by interviews and breath tests of a random sample of drivers. The relative risk of dying in a single-vehicle crash rose with increasing driver BAC. Males experienced a steeper increase in risk with each increase in BAC, when compared with females. Young drivers, ages 16 to 20 years, exhibited a sharper rise in risk with increasing BAC than did older drivers. The authors estimate that the risk of a fatal single-vehicle crash among male drivers, ages 16 to 20 years, more than doubles with each 0.02% increase in BAC. According to the 1999 YRBS, driving after drinking and riding with a driver who has been drinking are fairly common among high school students today. One-third of all high school students reported having ridden at least once during the 30 days prior to the survey with a driver who had been drinking (Kann, et al., 2000). About 13% reported driving after drinking themselves, a behavior that was more common among male students (17%) than among female students (9%). White students were more likely to report drink driving behavior than were black or Hispanic students. The prevalence of driving after drinking was higher among older than among younger students.

Clearly, motor vehicle-specific risk and safety behaviors are intricately linked with motor vehicle crashes and injuries. For this reason, the discussion to follow will highlight the antecedents and correlates of seatbelt use, reckless driving, and driving after drinking, in addition to those of motor vehicle crashes and injuries themselves.

Driving at night is an additional behavioral risk factor for MVCs. Williams (1985) analyzed data from the 1977 National Personal Transportation Study, a nationally representative sample of more than 24,000 households, and the FARS data, described above, for 1976-1978. For drivers of all ages, nighttime rates of fatal crashes per miles driven were higher than the corresponding daytime rates, suggesting that driving at night is a risk factor for fatal crashes among all drivers, including adolescents. This study also indicated that adolescents do more of their driving at night than do older drivers, and, at every age, males do more of their driving at night than do females. Notably, one cross-sectional study of 706 licensed drivers (65% European American, 25% Latino, 4% African American, 4% Asian American, and 2% other; 52% male) between the ages of 16 and 20 years suggests that driving at night may be related to driving after drinking (Grube & Voas, 1996). In this sample, those who drove most often at night were more likely than were their peers to report drinking and driving.

Adolescents who exhibit high levels of risk-taking behavior in general show higher levels of motor vehicle injuries in cross-sectional studies. Jelalian, Alday, Spirito, Rasile, and Nobile (2000) conducted two cross-sectional studies to evaluate the relationship between behavioral factors and motor vehicle injury. One study population was derived from one urban and two suburban high schools and included 1,576 students in the 9th through 12th grades. The ethnic distribution varied across the three schools, but was at least 50% white in each. Overall, the sample was about evenly split across genders, and represented a range of socioeconomic backgrounds. The second study population included 573 boys attending a parochial high school with a predominately white population. In each study population, adolescents who scored higher on a risk-taking scale, based on the frequency with which they reported engaging in each of six risky behaviors, were more likely than were their peers to have been injured in an MVC.

Jelalian and colleagues (2000) also identified a cross-sectional relationship between conduct problems and injury in an MVC. In the sample of the all boys parochial school, adolescent boys with more conduct problems were more likely than were their peers to report having been injured in an MVC. The connection between conduct problems and MVCs may be the result of an increased likelihood of risky driving.

Finally, marijuana use has been associated with drinking and driving among adolescents. One short-term, longitudinal study followed 1,359 10th and 11th grade drivers, primarily white and middle class, for five to six months (Klepp & Perry, 1990; Klepp, Perry, & Jacobs, 1991). Marijuana use at baseline was found to predict drinking and driving behavior in this study population.

As outline above, behaviors play an important role in motor vehicle safety. Studies suggest that beliefs and attitudes also matter in the context of adolescent drinking and driving, reckless driving, and seatbelt use—and thus are likely to be important in the context of motor-vehicle-related injury. The short-term longitudinal study described in the previous paragraph (Klepp & Perry, 1990; Klepp, Perry, & Jacobs, 1991) additionally identified several beliefs and attitudes that predict drinking and driving behavior, at least in the short term. Among the 10th and 11th grade participants, those who perceived a greater ability to drive after drinking and those who had lower self-confidence in their ability to avoid drinking and driving were more likely to report drinking and driving behavior.

Other beliefs and attitudes have shown correlations with drinking and driving behaviors in cross-sectional studies. Grube and Voas (1996) surveyed 706 licensed drivers between the ages of 16 and 20 years. The study sample was 52% male, and was 65% European American, 25% Latino, 4% African American, 4% Asian American, and 2% other ethnicities. Participants who believed that drunk driving is dangerous and those who believed that their friends would not approve of drunk driving were less likely than were their peers to drive after drinking or to ride with a driver who had been drinking. Similarly, those who perceived more available alternatives to driving after drinking or to riding with a drunk driver were less likely to exhibit these behaviors. A belief that drunk drivers are likely to get caught and be punished was associated with a decreased likelihood of riding with a driver who had been drinking, but was not associated with drinking and driving.

In a second cross-sectional study, however, beliefs about the certainty of punishment of drinking and driving were associated with drinking and driving behaviors in a distinct subgroup of adolescents. This study involved a survey of 12th graders, primarily Caucasian and about evenly split across genders, in 15 Midwestern communities (Grosvenor, Toomey, & Wagenaar, 1999). The analyses included the 4,292 students who were drivers and who reported alcohol consumption during the 30 days before the survey. Among the subgroup of adolescents who were binge drinkers (defined as having had five or more drinks during one drinking event in the two weeks before the survey), those who believed that their chances of being caught were higher reported less frequent drinking and driving than did their peers. These various cross-sectional findings highlight factors that deserve exploration in future rigorous, longitudinal studies.

At least one longitudinal study suggests that beliefs also may influence reckless driving behaviors. Gerard, Gibbons, Benthin, and Hessling (1996) obtained three annual waves of data from about 450 boys and girls from rural Iowa, half of whom were in the 8th grade and half of whom were in the 10th grade at study initiation. (The ethnic distribution of the study population was not detailed in the published report.) In this sample, beliefs about the prevalence of reckless driving predicted future reckless driving. Adolescents who believed that reckless driving was more common were more likely than their peers to report reckless driving behaviors one year later. Those who reported a stronger influence of overall health and safety concerns on their behavior were less likely to report driving recklessly one year later. Interestingly, increases in reckless driving were accompanied by increases in the perceived prevalence of reckless driving and declines in the influence of overall health and safety concerns, while decreases in reckless driving were accompanied by declines in the perceived prevalence and increases in the influence of health and safety concerns. Although the study design did not allow for a determination of which factor changed first (the behavior or the beliefs), the authors suggest that not only may beliefs influence behavior, but also adolescents may, in turn, adjust their beliefs in order to make them consistent with their changing behaviors.

Attitudes and beliefs also show associations with seatbelt use, at least in cross-sectional studies. One such study included 179 adolescent drivers from two suburban private schools, primarily white and of high socioeconomic status, and three urban public schools, two of which were inner city, low-income, and majority African American or Hispanic, and one of which was predominately white and middle class (Shin, Hong, & Waldron, 1999). In this sample, adolescents who reported greater perceived inconvenience associated with seatbelt use and those who reported greater fatalism (a belief that there is no point in wearing seatbelts since one has no control over one's future) were less likely to report seatbelt use. Conversely, those who ranked safety concerns as an important influence on their behavior were more likely to report wearing seatbelts. Notably, inner city students were less likely than were students in the private or middle-class schools to report wearing seat belts. These students also displayed a greater sense of inconvenience of seatbelt use, higher level of fatalism, and lesser value of safety concerns when compared with their peers attending private or middle-class schools. These correlates of seatbelt use should be assessed in future longitudinal studies.

Finally, numerous published reports (e.g., Jelalian, et al., 2000; Lang, Waller, & Shope, 1996) have noted a gender difference in MVC risk, with adolescent males experiencing a higher risk of MVCs than their female peers. As noted above, when compared with adolescent females, adolescent males are also less likely to wear seatbelts (Kann, et al., 2000; Maron, et al., 1986) and are more likely to drink and drive (Grosvenor, et al., 1999; Kann, et al., 2000; Klepp & Perry, 1990), to be at higher risk because of drinking and driving (Zador, et al., 2000), and to drive at night (Williams, 1985). The observed gender difference in MVC risk, then, may be due, at least in part, to a gender difference in patterns of risky behaviors and safety habits.

Family and Peer Antecedents and Correlates

A handful of studies have assessed the relationship between family and peer factors and MVC and related outcomes. Shope, Waller, and Lang (1996) followed 794 Michigan adolescents, 47% of whom were female, from 8th grade through the first year of driver licensure, most commonly to age 17. (The ethnic composition of the sample was not detailed in the published paper.) The study findings suggest that male adolescents who do not live with both parents are more likely to experience an MVC. Parental attitudes also appear to matter, as adolescent boys who reported that their parents had more negative attitudes toward drinking were less likely to have been in an MVC. Among adolescent girls, friends' influence was particularly important, as friends' reported involvement with alcohol—as measured by their feelings about alcohol, use of alcohol, frequency of offering alcohol to the participant, and other related factors—predicted risk of MVC in this gender group.

Having peers as passengers may also raise an adolescent driver's risk of being in an MVC. In an analysis of the 1990-1995 FARS national data, described above, Preusser, Ferguson, and Williams (1998) compared the distribution of passengers in at-fault fatal crashes to the distribution of passengers in not-at-fault fatal crashes. At-fault crashes included single-vehicle crashes and those in which the driver was assigned one or more FARS codes indicating a behavioral error on the part of the driver. Conclusions drawn from the analysis depend on a large assumption that involvement in a not-at-fault fatal crash is unrelated to passenger presence. Among adolescent drivers between the ages 16 and 19 years, driving with two or more adolescent passengers was associated with a heightened risk of at-fault fatal crashes when compared with adolescents driving with only one adolescent passenger, with a passenger(s) of some other age, or alone. The study authors suggest that adolescent passengers may distract young drivers or may encourage risky driving behaviors, including driving after drinking.

Cross-sectional studies suggest that family and peer factors may also be associated with seatbelt use behaviors. In the cross-sectional study of a diverse sample of 179 inner-city and suburban adolescents, described in detail above, adolescent students were more likely to report wearing their seatbelts if their parents used seatbelts and directed their adolescent children to use seatbelts (Shin, et al., 1999). Here, too, adolescents in the inner city, who were less likely to report seatbelt use, were less likely to report parental seatbelt use and direction to use seatbelts. In a second cross-sectional study regarding correlates of seatbelt use, Maron and colleagues (1986) surveyed 1,365 10th graders, 52% male and 48% female, in Santa Clara County, California. Participants were 71.1% white, 14.1% Asian, 4.8% Hispanic, 2% black, 1.5% Asian Pacific Islander, 1.2% Native American, and 5.3% other ethnicities. The sample represented a range of socioeconomic status but was of relatively high socioeconomic status, on average. In this sample, adolescents who reported that their parents used seatbelts and those who reported that their friends use seatbelts were more likely to use seatbelts themselves. Thus, parental and peer influence and modeling may affect adolescent seatbelt use behaviors. These factors deserve further study in a rigorous, longitudinal context.

Community and Neighborhood Antecedents and Correlates

Studies evaluating factors beyond the family and peer levels are few and far between. As noted above, students in private and middle class schools are more likely than students in inner-city schools to use seatbelts (Shin, et al., 1999). Both of the cross-sectional studies on seatbelt use discussed in this chapter found that adolescents of lower socioeconomic status, as indicated by parental educational attainment, are less likely to wear seatbelts (Maron, et al., 1986; Shin, et al., 1999).

There is a great need for additional research to investigate community and neighborhood factors that may influence adolescents' risk of MVCs and related outcomes. Potentially important variables may include community norms surrounding risk and safety behaviors and the condition of local roads. Numerous studies have evaluated policies relevant to adolescent MVCs. These studies will be described in the programs section, below.

Summary of Antecedents and Correlates of Motor Vehicle-Related Injury

In summary, risk and safety behaviors are closely linked with motor vehicle crashes and related injuries. Adolescents who drive recklessly, who drink and drive, or who exhibit a general propensity for risk-taking behaviors are at an increased risk of motor vehicle-related injuries, while those who wear their seatbelts enjoy a decreased risk. Driving at night or with peer-aged passengers are other behaviors that also increase risk. Additionally, adolescents who have conduct disorder are more likely than are their peers to be involved in motor vehicle crashes (MVC) and traffic offenses.

Beliefs and attitudes are also important. Various beliefs about the dangers and benefits of risky behaviors and about the availability of feasible alternatives to risky behaviors are associated with patterns of behavior, including drinking and driving, reckless driving, and seatbelt use. Parental and peer attitudes toward drinking are also associated with MVC risk among adolescents.

Various broader environmental factors are also likely to be important in the context of motor vehicle-related injury among adolescents. Further research should aim to identify these antecedents.

Antecedents and Correlates of Bicycle Injuries and Related Outcomes

The bulk of studies regarding factors associated with bicycle injuries and related outcomes are cross-sectional. The results of these studies should not be taken as definitive, but rather can be used to identify potential antecedents that deserve future exploration in a rigorous, longitudinal context.

Individual Antecedents and Correlates

A majority of the literature regarding bicycle injuries focuses on bicycle helmet use. Indeed, numerous studies have suggested that wearing a bicycle helmet decreases the risk of head injury in the event of a bicycle crash. For example, one case-control study assessed the helmet-use patterns of 757 cases, 119 of whom were 13- to 19-year-olds, who had been treated for bicycle crash-related head injuries in one of seven major hospital emergency departments in the Seattle area (Thompson, Rivara, & Thompson, 1996). The pattern of helmet use among these cases was compared to that among 2,633 patients, 428 of whom were between the ages of 13 and 19, who were treated in the same emergency departments for other bicycle crash-related injuries. (The ethnic distribution of the study participants was not detailed in the published report.) The results suggest that adolescents who are not wearing a helmet at the time of a bicycle crash are nearly 2.5 times more likely to incur a head injury and 2.7 times more likely to incur a brain injury than are their helmeted peers. The findings for other age groups were similar. For all ages combined, not wearing a helmet at the time of a crash was associated with a nearly four-fold increased risk of severe brain injury. Helmets offered similar protection irrespective of whether a motor vehicle was involved in the crash. Several other studies, including a case-control study of Australian children ages 14 and younger (Thomas, et al., 1994) and one of bicyclists of all ages in England (Maimaris, Summers, Browning, & Palmer, 1994), have also reported a protective effect of helmet use on risk of head injury. Based on studies like those cited above, the CDC has recommended that every bicyclist should wear a helmet that meets current standards—in every riding situation (CDC, 1995).

The prevalence of bicycle helmet use among adolescents who ride bicycles is alarmingly low. According to the 1999 YRBS, of the 71% of high school students who had ridden a bicycle during the year before the survey, 85% reported rarely or never wearing a bicycle helmet (Kann, et al., 2000). These data also suggest that black adolescents are less likely to wear a helmet than are their white peers.

These striking figures highlight the importance of identifying those factors that predict helmet use among adolescents and of designing, implementing, and evaluating helmet promotion programs. Reflecting the scope of the literature, the following discussion will focus on cross-sectional correlates of bicycle helmet use among adolescents.

In one cross-sectional study, Liller, Morisette, Noland, and McDermott (1998) evaluated correlates of bicycle helmet use among 3,005 bicycle-riding 6th and 7th graders from six middle schools in Hillsborough County, Florida. Low-, middle-, and high-income areas were each represented by two schools in the sample, which was about evenly split across genders and was 55.1% white, 20.2% Hispanic, and 16.4% black. Not surprisingly, having a helmet was strongly associated with the likelihood of having worn a helmet during the most recent bicycle ride. Intention to wear a helmet during the next bicycle ride was also strongly associated with helmet use on the most recent ride.

A second cross-sectional study (Gielen, et al., 1994) included 3,276 bicycle-riding children in the 4th, 7th, and 9th grades in three Maryland counties with varying bicycle helmet policies. The sample was nearly evenly distributed across genders and among the three grade levels, and was 81% white, 11% black, and 8% other ethnicities. In this sample, various helmet-related beliefs were related to helmet use on the most recent bicycle ride. Those who had stronger beliefs that helmets have a high protective value and are needed in a variety of riding situations were more likely to report having worn a helmet on the most recent ride. Those who expressed more negative beliefs about the social consequences of wearing a helmet—including how a helmet makes one look, how other kids will react to one's helmet, and discomfort in wearing a helmet—were less likely to report having worn a helmet on the most recent ride. These findings suggest that beliefs about the importance of helmet use and about the social acceptability and comfort of helmet use should be evaluated as potential antecedents of helmet use in future longitudinal investigations.

Family and Peer Antecedents and Correlates

The two cross-sectional studies detailed in the previous paragraphs also identified some family and peer level correlates of helmet use. In the survey of 6th and 7th graders in Hillsborough County, Florida, siblings' use of helmets and friends' use of helmets were strongly associated with helmet use on the most recent bicycle ride (Liller, et al., 1998). Similarly, analyses of helmet use among the 4th, 7th, and 9th graders from Maryland suggest that children and adolescents are more likely to report having worn a helmet on the most recent ride if they report that their friends, siblings, or parents wear helmets when bicycling (Gielen, et al., 1994).

Cryer and colleagues (1998) also identified a cross-sectional relationship between peer and family factors and adolescent helmet use among 3,082 bicycle-riding 7th and 11th graders in England. Helmet use was much less common among the 11th graders than among the 7th graders. Overall, adolescents whose closest friend wears a helmet and those who reported that their parents encourage helmet use were more likely, when compared with their peers, to report always wearing a helmet when riding a bicycle.

In an additional study, Harlos and colleagues (1999) observed bicyclists and recorded their helmet use at 190 inner-city and suburban sites in Winnipeg, Manitoba and 30 nearby rural sites, including parks, schools, residential streets, major intersections, and a handful of cycling paths. Of 2,629 observed cyclists, 439 were between the ages of 12 and 15 years and another 216 were 16 to 19 years old. Adolescents were the least likely of all age groups to wear helmets while bicycling. Among 12- to 15-year-olds, adult presence was associated with helmet use, as young adolescents who were riding with one or more adults were more likely than were their peers to be wearing a helmet.

These studies suggest that peer, sibling, and parental or other adult influence and/or modeling of helmet use may be important antecedents to adolescent helmet use behaviors. Future longitudinal studies of helmet use among adolescents should evaluate these factors as potential predictors.

Community and Neighborhood Antecedents and Correlates

In their observation of bicyclists in Winnipeg, Manitoba, Harlos and colleagues (1999) also found that helmet use was more common in urban than in rural areas, and in higher income than in lower income urban areas. Other broader environmental factors may be related to helmet use and to bicycle-related injury among adolescents and so also merit research attention. Future studies should explore the potential relationships between bicycle-related injury and such factors as community norms regarding helmet use, local road conditions, and the presence of bicycle lanes or sidewalks. Several studies have investigated the relationship between helmet policies and helmet use, particularly among children and young adolescents; these studies will be described below in the section on programs.

Summary of Correlates of Bicycle-Related Injury

In summary, essentially all of the available literature regarding factors associated with bicycle-related injury among adolescents focuses on the use of bicycle helmets. Wearing a bicycle helmet does indeed protect against head injury in the event of a bicycle crash. Cross-sectional studies suggest that adolescents who have a helmet, who believe helmets promote safety in a variety of situations, and who are less concerned about negative peer reactions to helmet use and about helmet discomfort are more likely to wear a helmet. Family and peer behaviors also may be important, as helmet use among peers and family members has been associated with adolescent helmet use in cross-sectional studies. Clearly, there is a strong need for longitudinal research to identify true antecedents of bicycle helmet use among adolescents.

Beyond Bicycle Helmets: A Need for Further Research

While bicycle helmets are clearly an important safety device, the use of which is directly associated to bicycle-related injury, there is a gap in the literature regarding other factors that may influence risk of bicycle-related injury among adolescents. Alcohol use is one potential antecedent worthy of further research attention. Studies have suggested that, among adults, alcohol use is associated with increased injury severity in the event of a bicycle crash (Spaite, et al., 1995) and that, among bicyclists ages 10 years and older, alcohol use is associated with an elevated risk of fatality in the event of a crash (Li, et al., 1996). This relationship may be due, at least in part, to an inverse association between alcohol use and helmet use (Li, et al., 1996). Examples of other factors that may play a role in risk of bicycle-related injury among adolescents include an inclination toward risk-taking while bicycling, such as riding quickly or weaving between cars, bicycling at night, road conditions, and the presence or absence of bicycle paths or lanes.

Antecedents and Correlates of Occupational Injuries

There is a growing interest in occupational injuries among adolescents, but to date the literature on this topic is quite limited. A handful of cross-sectional studies have begun to pave the way for research in this important area and have highlighted some potentially important factors associated with injuries among adolescents at work.

Layne and colleagues (1994) analyzed the patterns of nonfatal, emergency room-treated, occupational injuries among 14-17 year-olds in the U.S., based on data from the National Electronic Injury Surveillance System (NEISS), a nationally representative sample of U.S. hospitals. This analysis suggests that adolescent males, who experienced a rate of 7.0 injuries per 100 full-time employees over the course of six months, are at a higher risk of occupational injury than are adolescent females, who experienced a rate of 4.4 injuries per 100 full-time employees during the same time period. Employees in retail trade showed the highest rate of injury, with 6.3 injuries per 100 full-time workers over the six month period; the largest proportion (71%) of injuries in a retail job setting occurred in food and drink establishments. Other, more local surveys have noted similar results and provided some possible explanations for the observed gender difference.

One such cross-sectional study included 319 adolescents, between the ages of 16 and 19 years, who were full-time students in high school or college and were working for pay, at least 5 hours per week, in a formal organization (Frone, 1998). The study population was not randomly sampled but rather recruited through advertisements. Participants were 40% male and 68% white. In this group, too, adolescent males were more likely than their female peers to experience an injury at work. The study author suggested that gender differences in exposure to work hazards and in on-the-job substance use may explain, in part, this gender difference in injury risk. Adolescents who reported using alcohol or marijuana while working were at an increased risk of occupational injury, as were adolescents who reported exposure to more physical hazards at work. Both of these scenarios were more common among adolescent males. Other factors associated with elevated occupational injury risk in this study population were self-reported larger workload, more boredom at work, and less extensive supervisor monitoring.

Evensen, Schulman, Runyan, Zakocs, and Dunn (2000) conducted an additional cross-sectional study, surveying 117 15- to 17-year olds who worked in food and drink establishments, grocery stores, and other retail settings in North Carolina. (The ethnic composition of this sample was not detailed in the published report.) In this sample, too, exposure to a greater number of hazards was associated with a heightened risk of injury at work, and adolescent males were more commonly exposed to several specific job hazards. Consistent with Frone's (1998) finding that greater workload was correlated with injury risk, Evensen and colleagues found that adolescents who reported a more intense pace of work were more likely to have experienced an occupational injury. Finally, adolescents who worked in food service had a higher risk of injury and greater exposure to burn and cut hazards when compared with adolescents who worked in grocery or other retail.

These cross-sectional studies point to factors, including substance use, work hazards, work intensity, and supervision, that merit evaluation as potential determinants of occupational injury among adolescents. Other potential antecedents, outlined by Runyan and Zakocs (2000), may include worker characteristics (including body build and strength, risk-taking behaviors and beliefs, and sleep habits and sleepiness), extent of job safety training and worker education, and degree of enforcement of the Fair Labor Standards Act (FLSA) regulations.

Programs to Prevent Injury and Promote Safety Habits

Programs Targeting Motor Vehicle Crashes and Related Outcomes

Several program and policy approaches have been employed to promote motor vehicle safety and seatbelt use, discourage reckless driving and drinking and driving, and prevent injury due to MVCs. These programs have met with varying success.

Driver Education

Evaluations of high school driver education have yielded surprising results. Vernick and colleagues (1999) reviewed studies that evaluated the effects of driver education on adolescents, included a control group of some sort, controlled adequately for potential confounding factors, and did not rely on self-report to measure outcomes. Studies that met these criteria included two randomized controlled trials and five ecological studies that assessed differences in outcomes across time or region according to driver education status. Based on the results of these studies, Vernick and colleagues concluded that there is little evidence that adolescents who participate in a driver education course are less likely to be involved in an MVC or to have traffic violations than are adolescents who do not complete a driver education course. Quite the opposite, completion of a driver education course in high school may allow many adolescents to secure a driver's license that they would not otherwise be allowed to obtain until an older age. A number of states permit adolescents to procure a license at an earlier age if they complete a driver education course. Thus, the decrease in MVCs, if any, associated with driver education in high school is not sufficient to offset the increase in the per capita accidents that results from having more adolescent drivers licensed and on the road.

One of the studies supporting this conclusion was a randomized trial in DeKalb County, Georgia (Lund, Williams, & Zador, 1986). In this study, 16,338 high school students who applied for driver education and indicated a desire to obtain their license as soon as possible were randomly assigned to one of three conditions: the Safe Performance Curriculum (SPC), Pre-Driver Licensing Curriculum (PDL), or control. (The ethnic composition of this study sample was not detailed in the published report.) SPC consisted of 32 hours of classroom instruction, 16 hours of simulation instruction, 16 hours of driving range instruction, and three hours of instruction in evasive maneuvers, as well as three hours and 20 minutes of on-road instruction, 20 minutes of which were at night. PDL was a minimal driver education program, designed only to teach the skills needed to pass a licensure test, which consisted of 20 total hours of instruction, with only one hour of on-road instruction. Control students did not receive any high school driver education, but rather were left to learn from their parents, from a private driver training school, or not at all. Using state data on licensure, crashes, and violations, the study authors found that students assigned to either driver education group obtained licenses at a more rapid rate than did controls, but driver education participants did not have a decreased risk of MVCs or traffic violations. Overall, then, participation in driver education inspired earlier licensure among high school students, leading to more adolescent drivers on the road and a higher population crash rate.

As indicated by the review cited above (Vernick, et al., 1999), other studies, based on various study designs, have suggested similar effects of driver education. These include, for example, a comparison of adolescent licensure and fatal crash risk in states with differing proportions of students who completed driver education (Robertson & Zador, 1978) and an evaluation of changes in adolescent licensure and MVCs following the elimination of driver education in some Connecticut communities (Robertson, 1980).

Interestingly, driver education may alternatively act as an obstacle to licensure in cases where the introduction of driver education does *not* lower the age at which adolescents might obtain a license. In Louisiana, adolescents historically have been able to obtain a driver's license at age 15, irrespective of whether they have completed a driver education course. In 1993, however, the state passed a new law requiring 36 hours of driver education, with 6 hours of on-road instruction, as a prerequisite to licensure at this young age. Ulmer, Pruesser, Ferguson, and Williams (1999) compared the change in crash rates in Louisiana before and after the implementation of this law with the trend over time in crash rates in Mississippi, where licensure is allowed at age 15, and in Florida, where licensure is allowed at age 16. The imposition of the new requirement was associated with a decrease in the number of Louisiana 15-year-olds with driver's licenses, but did not appear to affect licensure among older adolescents. This change in licensure was associated with an overall, per capita decrease in crash rates in this state.

Summary of Evaluations of Driver Education

In summary, then, the available evidence suggests that offering driver education as a route to early licensure that otherwise would not be available expedites early licensure and leads to an increase in the population rate of MVCs. Imposing driver education as a new requirement to obtain licensure at an age when adolescents previously could procure a license without driver education may decrease rates of licensure at that early age, and lead to a decrease in the population rate of MVCs. The overarching finding is that the critical influence of driver education appears to lie in its effect on age at licensure. Importantly, studies have not indicated that completion of a driver education program reduces the risk of MVCs among licensed drivers. Vernick and colleagues (1999) caution, however, that two caveats should be kept in mind when considering the available findings. First, many driver education programs exist and most have not yet been evaluated. Second, an evaluation of high school driver education based on crash rates or traffic violations is not equivalent to an evaluation of the ability of driver education to convey basic driving information to new adolescent drivers.

Overall, the results concerning driver education suggest that delaying licensure may be an effective strategy to reduce population risk of MVCs. Graduated driver licensing is one approach designed to delay the full and complete licensure of young adolescents.

Graduated Driver Licensing and Curfew Laws

A graduated driver licensing system can be and has been constructed in a wide variety of ways, but in general has a minimum of three essential stages. These stages include a preliminary period of supervised driving, followed by a period of unsupervised driving that is restricted to lower risk situations, such as daytime driving and/or driving without adolescent passengers, and finally full and complete licensure (Foss & Evenson, 1999).

There is some evidence to suggest that graduated licensing may have a desirable influence on MVC risk among the new adolescent drivers affected by the law. For example, Ulmer, Preusser, Williams, Ferguson, and Farmer (2000) followed the MVC experience in Florida from 1995 to 1997, to assess the effect of a graduated licensing program, implemented in Florida in 1996. The authors compared changes in Florida crash rates, from pre- to post-implementation, with changes over the same time period in the crash experience in Alabama, a state with no graduated licensing program. The Florida graduated licensing program required 15- to 17-year-old drivers to have a learner's permit for six months. The law disallowed driving between 7 p.m. and 6 a.m. during the first three months of this learner's permit period and disallowed driving between 10 p.m. and 6 a.m. for the second three months. Driving between 11 p.m. and 6 a.m. was prohibited for 16-year-old drivers and unsupervised driving between 1 a.m. and 5 a.m. was prohibited for 17-year-old drivers. Penalty points for moving violations had an enhanced effect for these young drivers, who could lose their licenses after many fewer infractions than under the former rules. Finally, a "zero tolerance policy", meaning a maximum allowed blood alcohol concentration of zero, was put in place for drivers under the age of 21 years. In Florida, between 1995 and 1997, there was a decline in the ratio of the MVC rate for 15- to 17-year-olds to that for drivers ages 25 to 54. Over the same time span, there were no significant changes in the relative MVC rate among Florida 18-year-olds, who were unaffected by graduated licensing, or for adolescents of any age between 15 and 18 years in Alabama. The observed declines in MVC risk among adolescents ages 15 to 17 years in Florida were more pronounced for white than for nonwhite adolescents and were greatest for crashes in urban rather than rural areas, and for crashes occurring at night rather than during the day. These changes were not associated with a decline in licensure, suggesting that some component(s) of the graduated driver licensing program itself may be responsible for the desirable change in MVC risk. However, it is unknown which of the many components of the system are effective.

Indeed, in a recent review of graduated licensing program evaluations, Foss and Evenson (1999) conclude that the evidence to date is not sufficient to determine whether graduated licensing programs have an effect on MVCs and associated injuries or fatalities. The long-term repercussions of these programs are also as yet unknown. Foss and Evenson suggest that the diversity of graduated licensing systems that states are implementing should provide an opportunity to evaluate which of these programs, if any, are effective, and which components and parameters of any successful programs appear to be exerting a desirable effect.[9]

A nighttime restriction on adolescent drivers is one component, common to many graduated licensing systems, which has been evaluated separately. In one study regarding curfew laws, Preusser, Williams, Zador, and Bloomberg (1984) assessed the patterns of police-recorded MVCs among 16 year-old drivers in several matched states with and without curfew laws. New York and Pennsylvania, each with curfew laws, were compared with Ohio, a state without a curfew law. Similarly, Louisiana was compared with Mississippi. The pattern of MVCs in Maryland was compared before and after implementation of a curfew law. Primarily in New York and Pennsylvania as compared with Ohio, the presence of a curfew law was associated with a decreased risk of MVCs during the curfew hours. This decreased crash involvement was observed among 16-year-old drivers but not among older drivers. These findings suggest that curfew laws may be variably associated with decreased crash risk, but limitations in the study design should inspire careful interpretation of the findings. The analyses were not multivariate and the effects of the curfew laws in New York and in Pennsylvania were compared only with a single comparison state (Ohio).

In a second study of curfew laws, Preusser, Zador, and Williams (1993) compared data on fatal MVCs from the 1984-1990 FARS, described above, for cities with and without curfew ordinances for adolescent drivers ages 17 and younger. All of the 124 cities included in the study had a population of 100,000 or larger, and none was covered by a statewide curfew law. Cities with curfew ordinances had fewer nighttime highway fatalities among adolescents ages 13 to 17 years than did cities without such ordinances. During the daytime, there were no significant differences in adolescent highway fatalities across cities with and without curfew laws.

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[9] The following website offers a detailed listing of current licensing laws for young drivers, by state: http://www.highwaysafety.org/safety_facts/state_laws/grad_license.htm

These two studies have suggestive results that indicate that curfew laws may be effective in preventing MVCs among adolescents at night. Further rigorous study should evaluate this claim.

Programs and Policies to Prevent Drinking and Driving

Several programs to prevent drinking and driving have been carried out and assessed. Some program evaluations have simply surveyed students as to their pre-program behavior and post-program intentions or attitudes, neglecting to assess the program's impact, if any, on actual behavior (e.g., Wodarski & Bordnick, 1994; Yates & Dowrick, 1991). Others have assayed actual behavioral outcomes, and have indicated varying levels of program effectiveness.

School-Based Programs

The Alcohol Misuse Prevention Study (AMPS) curriculum was implemented and evaluated in 10th grade classes in six school districts in southeastern Michigan between 1988 and 1990 (Shope, Elliot, Raghunathan, & Waller, 2001). Classes were randomly assigned to the program or control groups. The AMPS curriculum consisted of five 45 minute sessions over five consecutive days, and was designed to raise student awareness of the short-term repercussions of alcohol use, of the risks associated with alcohol misuse, and of commonly encountered alcohol use situations and social pressures. The program also aimed to teach students useful skills for dealing with these common pressures and situations. Curriculum activities and materials included worksheets, pamphlets, games, class discussions, role plays, and use of audio-visual materials. Participants who procured a driver's license by June, 1997 were included in the present analysis of state-reported outcome data for traffic offenses and MVCs between 1986 and 1997. These 4,635 students were 83% white and 17% nonwhite, and the vast majority obtained their driver's licenses within one year of the intervention, on average at age 16.4. During the first year of licensure only, program students experienced fewer serious offenses when compared with control students. Relevant offenses included those that involved alcohol, were classified as "serious" by the Secretary of State's office (such as reckless driving or vehicular homicide), led to the assignment of three or more points to the driver, or concerned drug offenses not associated with driving. The program effect was stronger among students who reported drinking less than one drink per week at baseline and among the small minority of students whose parents had not shown disapproval of alcohol use. The dissipation of impact after the first year of licensure suggests that booster sessions may be indicated.

Plan a Safe Strategy (PASS) is another program designed to prevent drinking and driving behaviors and targeted to 10th graders (Sheehan, et al., 1996). The evaluation of the PASS program was carried out in Australia, where 1,774 10th grade students, ages 14 to 15 years and 59% female, were randomly assigned to program and control groups and followed up three years later. The PASS program included 12 lessons designed to modify attitudes toward drinking and driving, beliefs about drinking and driving risks, perceived norms about drunk driving attitudes, and perceived control over drinking and driving and passenger behaviors. The program activities included role playing and other interactive activities, which emphasized pressure-resistance skills and the development of plans to use alternatives in drunk driving and passenger situations. While there were no significant program effects on drinking and driving at the three-year follow-up, analyses did suggest a program effect on continued patterns of riding with a driver who had been drinking. Among those participants who reported having ridden with a drinking driver at baseline, program students were less likely than were control students to report having ridden with a drinking driver in the month before the follow-up survey, three years later. These findings are promising, although it should be noted that a sizable fraction of the students who originally participated in the study were not available to complete the follow-up survey. Moreover, cultural differences may affect the generalizability of these findings from Australia to the U.S.

A third program was peer-based and integrated into a high school driver education course (McKnight & McPherson, 1986). Participants included 667 students, enrolled in driver education in five Rhode Island high schools, who were randomized to the "Peer Intervention Program" or a conventional, information-oriented program control group. (The ethnic and gender compositions of the sample were not detailed in the published article.) The Peer Intervention Program was nine hours long and included one hour of instruction in fundamental alcohol safety and eight hours of role playing and discussion regarding intervention in drinking and driving situations. Immediately after the program implementation, students in the program and control groups showed significant increases in self-reported intervention in the drinking and driving behavior of others. At follow-up one to four months later, only students in the program condition continued to show a sustained increase in self-reported intervention in drinking and driving situations. The authors conclude that the Peer Intervention Program had desirable effects on the behavior of participants in drinking and driving situations, sustained over the short-term, while any desirable effects of the standard information-based program dissipated almost immediately. These findings are indeed suggestive; however, further study will be needed to assess the longer-term effects of this program and to evaluate the extent to which self-reported behaviors might have biased the present findings.

Students Against Driving Drunk (SADD) is a well-known program that bridges the school and the community in drinking and driving prevention efforts. We are aware of only one study to date that evaluated a SADD program (Klitzner, Gruenewald, Bamberger, & Rossiter, 1994). One program and one comparison school each in California and in New Mexico were matched on school size, percent white, socioeconomic status, academic ranking, grade levels, and urbanicity. The California schools were suburban and predominately white; whereas, the New Mexico schools were in a low socioeconomic status, rural area and were one-third Hispanic and two-thirds white. As originally envisioned, the SADD program was to include four components: 1) a kick-off assembly designed to motivate interest and attention to the issue; 2) the formation of student chapters to coordinate school and community events; 3) a 15 session, 10th grade curriculum designed to communicate the negative consequences of drunk driving and to incorporate role play activities; and 4) the signing of a contract in which the student and his/her parents pledge to have a parent provide transportation in cases where the student has been drinking. In reality, the California program school implemented some, but not all, of the SADD program and the New Mexico program school implemented very little of the program. Moreover, the California comparison school initiated some of its own drinking and driving prevention activities during the evaluation period. Acknowledging these limitations, the evaluation suggested that SADD had no measurable effect on drinking and driving behavior or on other related measures. Further study should assess whether SADD is at all effective when implemented more fully and should evaluate the feasibility of more thorough implementations.

Community-Based Programs

At least two relevant community-level programs have included an assessment of outcomes among adolescents. The Saving Lives Program (Hingson, et al., 1996) was implemented and evaluated among six Massachusetts communities, predominately white, that had applied for and received funding for a community MVC prevention program. These six communities were left to initiate their own program activities, which included mass media campaigns, business information programs, awareness days, speed watch hotlines, police training, high school peer-led education, SADD chapters, alcohol-free proms, beer keg registration, and heightened liquor outlet surveillance. Over the period from program implementation in 1988 to follow-up in 1993, these communities saw a decline, relative to the rest of Massachusetts, in the percentage of 16- to 19-year-olds who reported drinking and driving in the previous month. There were also overall decreases in fatal crashes involving alcohol. Since the composition of this program varied across program communities, the interpretation of these results is somewhat problematic. The authors suggest that the very process of community organizing, itself, may exert an effect on the measured outcomes; however, future study is needed to disentangle the effects of the community organizing process and of the multiple program activities.

In another community-based program evaluation, 15 Midwestern communities were randomized to a community organizing program ("Communities Mobilizing for Change on Alcohol") or control condition (Wagenaar, Murray, & Toomey, 2000). Community organizers, hired in each program community, worked with several community institutions, including local public officials, law enforcement, alcohol merchants, the media, and local schools, to affect community policies and reduce underage access to alcohol over the course of 2.5 years. During the program implementation period, there were changes in alcohol retail policies and practices, in media attention to alcohol issues, and in law enforcement practices. The study authors obtained city data on arrests and traffic crashes for the six years prior to and the three years spanning the program implementation. When compared with the control communities, the program communities saw a decline in drunk driving arrests among young people ages 18 to 20 years and among adolescents between the ages of 15 and 17 years. There was no measurable impact on MVCs, although the authors note that the study did not have a strong ability to detect any changes in MVC occurrence.

Policy Measures

The primary policy approach directed specifically at drinking and driving behaviors among adolescents and young adults has been a lowering of the legal blood alcohol concentration (BAC) limit for young drivers. Several non-randomized studies have ventured to assess the effects of these laws. Hingson, Heeren, and Winter (1994), for example, compared the fatal

MVC experience of each of 12 states that lowered the legal BAC limit for young drivers before 1991 with the fatal MVC experience of a neighboring state that did not enact a similar policy change. The authors examined state-level data from FARS, described above, for all available years after the policy change and an equal number of years before the policy change in a given state. Fatal, single-vehicle crashes at night were used as a proxy for alcohol-related crashes, based on the argument that about half of fatal, single-vehicle, nighttime crashes among 15- to 20-year-olds involve alcohol use. In states that had lowered the legal BAC limit for young drivers, there was a drop in the percentage of adolescent fatal crashes that were single-vehicle crashes at night, relative to comparison states. There was no parallel decline among drivers 21 years and older, who were not targeted by the policy change. Moreover, the states that exhibited the largest law effects were those with the lowest BAC limits, of 0.0% or 0.02%. States with BAC limits of 0.04% to 0.06% showed little effect.

These findings suggest that lowering the legal BAC limit for young drivers may reduce alcohol-related MVC fatalities in this age group. Indeed, in a recent review of evaluations of such policy changes, Zwerling and Jones (1999) found that, although the available literature has important limitations, several non-randomized studies have suggested an effect of lower BAC limits on MVCs and/or associated injuries and fatalities. The authors indicate that these findings have been consistent across geographic areas, time, varying law specifications, and differing study designs. This replication bolsters the argument for the effectiveness of lower BAC limits.

Notably, a lower legal BAC limit for young and inexperienced drivers is among the approaches recommended by the Task Force on Community Preventive Services—an independent panel of experts, supported by the DHHS and CDC, that provides recommendations for community-level, public health interventions based on rigorous, systematic reviews of the research literature (Shults, et al., 2001; see also Task Force on Community Preventive Services, 2001). Furthermore, the Task Force strongly recommends both the enforcement of BAC limit laws via sobriety checkpoints and the preservation of a complementary policy that sets the minimum legal drinking age at 21 years.

Summary of Programs to Prevent Drinking and Driving

In summary, some school-based programs to prevent drinking and driving have met with success. These programs have aimed to increase awareness of the risks associated with drinking and driving and to prepare adolescents with ways to deal with drinking and driving situations and with the pressures commonly encountered in these situations. One such program led to a decrease in serious traffic offenses, including drinking and driving, and a second program led to a decrease in riding with a driver who had been drinking.

Community organizing programs have also shown promising results. In these programs, communities, with or without the help of a community organizer, initiate a variety of activities to prevent drinking and driving, such as mass media campaigns, awareness days, modifications to alcohol retailer policies and practices, and law enforcement changes. While this general approach has been successful in one quasi-experimental and one randomized trial, further research is needed to identify which component(s) of this program are exerting the desirable effect.

At the policy level, a number of non-randomized studies have indicated that lowering the legal blood alcohol concentration for young drivers may reduce motor vehicle-related fatalities. This finding has been replicated under a variety of conditions and is consistent with evidence-based public health recommendations offered by the Task Force on Community Preventive Services.

Programs and Policies to Promote Seatbelt Use

Few programs designed to promote seatbelt use among adolescents have been implemented and evaluated. Those that have been carried out and assessed have not necessarily been evaluated in a rigorous manner (e.g. Wojtowicz, Peveler, Eddy, Waggle, & Fitzhugh, 1992). For these reasons, the discussion to follow will describe just one school-based seat belt promotion program as well as the effects of legislation to promote seatbelt use.

In a school-based seatbelt promotion effort, Martinez, Levine, Martin, and Altman (1996) evaluated the effects of a one-week educational program that was integrated into a high school physics class. Program participants included about 120 11th and 12th graders who were followed from baseline to two weeks and then to six months after the program initiation. About 70 students enrolled in a physics curriculum at a similar school served as a comparison group. The overall sample was about 60% male and 65% white. The program involved instruction regarding the physics of motor vehicle crashes, an evaluation of the safety features of passenger vehicles, a rollover demonstration, and a project in which students aimed to design a "vehicle" that would keep an egg intact during a six-story fall. When compared with students in the control group, program participants experienced an increase in self-reported seatbelt use at both the two-week and the six-month follow-up. This finding suggests that an interactive curriculum may encourage seatbelt use behaviors, at least in the short term, among some adolescent students. Further study is necessary to confirm the effectiveness of this program.

In an evaluation of the effect of seat belt laws on overall fatal injury rates, Houston, Richardson, and Neeley (1996) examined the fatal MVC experience, based on FARS data, for all 50 states between 1975 and 1991. Although this study did not specifically measure outcomes among adolescents, it is a high quality study with interesting results and so warrants mention. After controlling for a myriad of potential confounding factors, including other motor vehicle-related policies, state expenditures for road safety measures, age and income distributions of the state populations, population density, population alcohol consumption, and climate, Houston and colleagues found that seatbelt laws were associated with desirable trends in fatal MVCs. Several findings support this assertion. First, the existence of a seatbelt law in a given state was associated with a significantly lower occurrence of motor vehicle-related fatalities in that state. Second, the effect on the fatality rate was larger in states that allowed primary enforcement, where an individual can be stopped and ticketed simply for violating the seatbelt law, than in states where enforcement was only secondary, meaning that ticketing for violation of the seatbelt law is allowed only if an individual has been pulled over for another reason. Finally, laws that applied to the back seat as well as the front seat were associated with a more sizable decrease in fatal injuries than were laws that applied only to the front seat. Of note, seatbelt laws were associated with an increase in the rate of serious injuries in fatal MVCs. The study authors propose that this effect is likely due to an increase in seatbelt use, which decreases the risk of death in cases of serious injury that, without the use of a seatbelt, would have been fatal. Thus, in serious crashes that could lead to fatality, seatbelt use may prevent death, allowing for survival but with serious injury. Notably, based on a systematic review of the research literature, the Task Force on Community Preventive Services (described above) strongly recommends the implementation of seat belt laws—accompanied by rigorous, primary enforcement of these laws—as an effective approach to increase seatbelt use (Dinh-Zarr, et al., 2001; see also Task Force on Community Preventive Services, 2001).

Overall, while the available research suggests that seatbelt laws may be a viable intervention to promote seatbelt use, there is a need for further implementation and evaluation of programs, at all ecological levels, designed to promote seatbelt use among adolescents.

Programs to Promote Bicycle Helmet Use

To our knowledge, programs that have been implemented and evaluated in the published literature and are designed to prevent bicycle-related injury among adolescents focus almost exclusively on the promotion of bicycle helmet use. These programs tend to target only young adolescents, groups of children and young adolescents combined, or just younger children. Evaluations of programs designed to promote helmet use among older adolescents, and evaluations of programs to prevent bicycle-related injury via alternative approaches, are lacking.

The available programs that target young adolescents or children and young adolescents together have focused on three general approaches: education, legislation, and the dispensing of helmets at a reduced or no cost. Moore and Adair (1990), for example, evaluated a multi-component, school-based program intended to encourage helmet use among 11- to 13-year-olds attending an inner-city intermediate school in New Zealand. The program included a school assembly regarding the use and benefits of bicycle safety equipment and a two-week period during which lessons on bicycle maintenance, riding rules, and safety equipment were incorporated into class sessions in a variety of school subjects. Other program components entailed bicycle inspections, a school bicycle rally, the distribution of coupons for 10% off of a helmet purchase, and an eight-week period during which children seen wearing helmets while riding to school were rewarded with passes to entertainment centers. Observations of the helmet usage of bicyclists leaving the program school at the end of the school day were compared with similar observations of bicyclists leaving a comparison school of a comparable size, school level, and community socioeconomic status. These observations suggested that there was an increase in helmet use in the program school, relative to the comparison school, particularly among girls. Observed helmet use in the program school increased from 3.5% at baseline to 33.3%, ten weeks after the initial school assembly. Although this finding is suggestive, its interpretation is complicated by the fact that a student at the program school was involved in a serious bicycle accident during the evaluation period. This tragedy may have influenced helmet use patterns in the program school.

Logan and colleagues (1998) evaluated the effect of giving away bicycle helmets to 403 students attending kindergarten through 8th grade in two small Texas towns. The program involved a full school day during which students were fit for helmets, exposed to bicycle safety information, and given free helmets. Over the period between two weeks following the program and six months later, raffle tickets to enter drawings for money prizes were given to children who were observed wearing helmets while bicycling. Observations of helmet use were made at baseline and at one day, two weeks, seven months, and nine months following the initial full-day program. An initial rise in helmet use occurred among the younger children, but not among the adolescent 7th and 8th graders. The possible effect among the elementary school-aged children dissipated by the final follow-up, nine months after the program. This finding suggests that the program was only effective among younger children, and led only to transient improvements in helmet use even among this age group.

Abularrage, DeLuca, and Abularrage (1997) assessed the effect of implementing a bicycle helmet education and coupon program in an area with a newly implemented bicycle helmet law requiring children ages 14 and younger to wear a helmet when bicycling. In this program, 14 randomly selected elementary and junior high schools in Queens, NY—the most racially diverse county in the United States, according to 1990 census data—were exposed to a week-long educational campaign. The program involved the distribution of prescriptions for bicycle helmets from local pediatricians and of packets that contained a $10 coupon for use toward a helmet purchase as well as information regarding bicycle safety, helmets, and the new helmet law. Ads ran in local newspapers to promote helmet use and raise awareness of the helmet law, and 75 raffle winners had the opportunity to attend a "Bicycle Helmet Day" celebration. Observations of helmet use were made during the week before the program and about 2-2.5 months later both in Queens and in Kings County (Brooklyn), NY, which served as a comparison community that was affected by the new law but not exposed to the education and coupon program. About 300 observations were made for each study condition at each point in time. Over the study period, the percentage of 10- to 14-year-old bicyclists observed wearing helmets rose from 0.7% to 7.9% in Queens, and fell from 4.4% to 0.5% in Brooklyn. The increase in helmet use in Queens was particularly pronounced among girls. The authors suggest that the education and coupon program improved helmet use, while the new helmet law—though only minimally enforced—did not appear to improve helmet use in the control community.

Other studies, however, have suggested the helmet laws may influence helmet use among children and young adolescents. In one such study (Ni, Sacks, Curtis, Cieslak, & Hedberg, 1997), researchers observed helmet use among bicyclists before and after the implementation of an Oregon law that required children younger than 16 years to use a helmet when bicycling on public property. The penalty for a violation was a $25 fine. According to observations made at 33 middle schools just before the implementation of the law and again one year later, there was an increase in helmet use among young adolescents from about 20% during the pre-law period to 56% one year later. Because there was no comparison group, the increase in helmet use cannot necessarily be attributed to the helmet law. In a recent review, researchers in the field conclude that several studies suggest that helmet laws can encourage helmet use (Rivara, Thompson, Patterson, & Thompson, 1998). A review of the literature by researchers at the CDC also supports the assertion that legislation can be an effective helmet-promotion tool, especially when accompanied by an educational campaign (CDC, 1995). Overall, while the results described here are encouraging, further study will be needed to assess the relationship between helmet laws and helmet use among adolescents in particular.

Of note, the CDC has published recommendations that encourage the implementation of multifaceted programs, at the state and community levels, that aim to promote helmet use through a combination of legislation and enforcement (via education rather than punishment), education and awareness campaigns, and helmet coupons or giveaways (CDC, 1995). This recommendation is consistent with the review of the literature described in this report.

Summary of Programs to Promote Bicycle Helmet Use

In summary, multiple helmet promotion approaches, including educational programs and legislation, have shown promising results when evaluated. Pure helmet giveaway programs, however, have met with variable results (see Rivara, et al., 1998 as well as Logan, et al., 1998). Interestingly, several studies have found greater effects of helmet promotion efforts on helmet use among girls. Consistent with the available research literature, the CDC recommends the implementation of *multi-component* programs to increase helmet use through a combination of legislation, education, helmet coupons or giveaways, and awareness campaigns. Future research efforts should employ randomized designs when possible and should focus on older adolescents as well as younger adolescents and children.

There is also a hole in the literature regarding other approaches to preventing bicycle-related injury among adolescents. Programs designed to promote other elements of safe bicycle riding, such as abstaining from use of alcohol before bicycling and avoiding fast and risky riding in traffic, should be implemented and evaluated, as should environmental modifications, such as the construction of bicycle lanes and paths.

Programs to Prevent Occupational Injury

Consistent with the literature search findings of a recently published review (Runyan & Zakocs, 2000), a current review of the literature turned up only one published paper regarding a program designed to prevent occupational injury among adolescents. The Safe Teen Work Project was intended to reduce the occurrence of cutting injuries among adolescents employed at grocery stores (Banco, Lapidus, Monopoli, & Zavoski, 1997). The study authors note that cutting injuries are common among adolescents who use case-cutters in their work at grocery or general merchandise establishments. Nine stores of a single grocery chain in Connecticut were randomly assigned to one of three conditions. Three stores received new, safer case-cutters and a 15-minute employee training regarding safe handling and use of the case-cutters. A second group of stores continued to use their usual case-cutters, but did receive a 15-minute employee training in safe handling of the equipment. The third group of stores continued to use the usual case-cutters and received no employee training. (The ethnic composition of the sample was not described in the published report.) Store logs provided data on lacerations during the period spanning two years before through one year after the intervention. According to these data, stores that received new equipment along with employee training saw a larger decline in the rate of laceration injuries among employees than did stores in the other two experimental conditions. Moreover, a cost-effectiveness analysis suggests that the program is very cost-effective, as those stores that received new equipment and benefited from employee training experienced net savings. There are two important caveats to consider, however, when interpreting the present results. While 31% of employees injured during this time were younger than 20 years of age, the ages of injured workers spanned from 16 to 78 years. Thus, although the program was targeted to adolescent workers, the program effect was not evaluated for adolescent workers alone. Additionally, the analysis did not include a measure of statistical precision.

Clearly, there is a dearth of literature regarding promotion of safety in the workplace for adolescents. Future research should involve the development, implementation and evaluation of programs to address adolescent injury risk at work. Possible approaches might include programs designed to reduce exposure to hazards at work, raise awareness of safe work practices among employed adolescents, discourage on-the-job substance use, increase supervision, and enhance enforcement of existing protection laws or create new policies to protect adolescents at work.

Common Themes

The above discussion highlights the critical importance of behaviors in the context of adolescent injury risks. Risky behaviors of various sorts are risk factors for unintentional injuries overall and for injuries in specific settings. Alcohol use, for example, is a common risk factor associated with several types of injury, including but not limited to motor vehicle-related injury (e.g., Lang, et al., 1996; Zador, et al., 2000), drownings (Wintemute, Kraus, Teret, & Wright, 1987), and injuries at work (Frone, 1998). Safe behaviors are also vitally important. Adolescents who wear seatbelts and bicycle (and motorcycle) helmets and who don't drive recklessly or after drinking decrease their risk of injury, serious injury, and fatality.

In general, the burden of injuries is not shared equally across gender groups. Among adolescents and other age groups, males are at an increased risk of unintentional injury overall and of specific injury types, including motor vehicle-related and work-related injuries. As many of the studies explored here have suggested, this gender difference likely reflects, at least in part, a gender difference in risky behaviors and safety habits. Adolescent boys, for example, are less likely than are their female peers to wear seatbelts consistently and more likely to drink and drive and to use substances while on the job. This again points to the importance of behavior in the context of adolescent injury.

Yet injury risk and the behaviors that influence this risk likely reflect influences at multiple levels. Several studies suggest that peer, sibling, and parental modeling and influence might affect risk and safety behaviors. Moreover, environmental conditions and hazards are most certainly important contributors to injury risk. Policies also seem to be important, as the evidence to date suggests that policies such as graduated driver licensing systems and laws regarding driving curfews, drinking and driving, and use of seatbelts and helmets may indeed influence behavior and mitigate risks of injury and injury death.

Finally, there is a clear and overarching need for additional quality research to elucidate the various determinants of adolescent injury and associated behaviors and to identify effective program strategies to promote safety and prevent injury during adolescence. Rigorous studies that employ a longitudinal design, and program evaluations that are randomized and appropriately controlled will add greatly to our current knowledge in topical areas that have been explored using other approaches. Moreover, high quality studies should also address topics that have remained relatively untapped in the unintentional injury literature regarding adolescents. For example, community and societal factors, such as media messages and community norms, deserve further research attention, as do environmental modifications, such as the construction of bicycle paths or the reduction of exposure to hazards at work.

Conclusion

In summary, adolescence is a stage characterized by general good health. However, adolescence is a key time for the promotion of a healthy lifestyle, as many life-long health behavior patterns begin to be established during this developmental stage. Moreover, a large fraction of the disability and death that does occur during adolescence could be alleviated through effective injury prevention. Although the available research can provide us with some important and useful knowledge to work from today, there is a dire need for more, high quality research to guide and inform health behavior promotion and injury prevention during the critical period of adolescent development.

Summary Table: Review of the Research Literature and Implications for Targeted Activities to Promote a Healthy and Safe Lifestyle and to Prevent Injury Among Adolescents

AREAS FOR TARGETED INTERVENTION ACTIVITIES	WHAT WORKS	WHAT DOESN'T WORK	MIXED REVIEWS	BEST BETS
Tobacco Use	- Multi-component, school-based programs (like Life Skills Training and Project Toward No Tobacco Use) that address peer pressure and other social influences to use tobacco, anxiety management, self-esteem building, communication skills, development of personal relationships, and/or misperceptions about norms and about the consequences of tobacco use. [However, further research is needed to explain the apparent success of these programs given the failure of similar programs (see "What Doesn't Work" column).] - Community program components that supplement school-based programs with media messages and other community activities.	- Fear-based strategies that simply provide factual information about the dangers of tobacco use - Local interventions to prevent tobacco sales to minors by increasing measured retailer compliance with the law. - Pure "social influences" programs (like the Hutchinson Smoking Prevention Project), designed to counteract the social influences to use tobacco by enhancing resistance skills and correcting exaggerated perceptions of how common tobacco use is.		*Individual Level* - Promote positive attitudes toward non-smoking and non-smokers. - Treat and prevent adolescent depression and anxiety and childhood conduct problems. *Family Level* - Enhance parental monitoring and consistent discipline, as well as parental anti-smoking attitudes. - Reduce parental smoking through prevention and cessation programs. *Peer Level* - Reduce tobacco use among peers via the other approaches detailed here. *Broader Environmental Levels* - Eliminate tobacco industry advertisements that target minors.
Physical Activity and Nutrition	- Multi-component, school-based programs designed to promote cardiovascular health through school environmental changes (e.g. training of PE teachers and food service personnel and modification of PE curriculum and content of school meals) and classroom curricula that addresses psychosocial factors and behavioral skills relevant to physical activity, nutrition, and other components of cardiovascular health.	- Simply conveying health information in an attempt to increase knowledge.		*Individual Level* - Enhance perceived ability to be physically active (self-efficacy). - Assist adolescents in setting and working toward a specific behavior-change goal.

AREAS FOR TARGETED INTERVENTION ACTIVITIES	WHAT WORKS	WHAT DOESN'T WORK	MIXED REVIEWS	BEST BETS
Sleep			- Changing school start times (preliminary results suggest both positive and negative consequences).	*Individual Level* - Reduce tobacco use through prevention and cessation programs. - Treat and prevent adolescent depression. - Address other behavioral and emotional problems, including rebelliousness and stress. - Alleviate—or improve management of—time pressures resulting from the demands of school-work, employment, and other activities.
Dental Health Behaviors—Brushing, flossing, and visiting the dentist.				*Individual Level* - Implement programs that incorporate behavioral components, such as training in personal dental hygiene and in self-evaluation of dental health and hygiene, as well as the provision of information regarding dental health and hygiene. *Broader Environmental Levels* - Address barriers to use of professional preventive care and professional application of sealants, especially those barriers among adolescents of lower socioeconomic status.

AREAS FOR TARGETED INTERVENTION ACTIVITIES	WHAT WORKS	WHAT DOESN'T WORK	MIXED REVIEWS	TO BE TRIED
Unintentional Injuries, Risk Behaviors and Safety Habits—Overall, and motor vehicle-related	**- School-based programs designed to prevent drinking and driving behaviors by increasing awareness of the risks associated with drinking and driving and by preparing adolescents with ways to deal with drinking and driving situations and the pressures commonly encountered in these situations. [Can decrease serious traffic offenses and occurrence of riding with a drunk driver]** - Community organizing programs in which communities, with or without the help of a hired community organizer, initiate a variety of activities to prevent motor vehicle crashes and related outcomes or behaviors. Possible community activities include mass media campaigns, awareness days, modifications to alcohol retailer policies and practices, and law enforcement changes. [Can decrease drinking and driving behaviors.]	**- Students Against Driving Drunk (SADD), at least when not fully implemented.**	**- Driver Education. [Effect depends on driver education's influence on age at licensure.]**	***Individual Level*** **- Prevent risky behaviors (such as substance use and reckless driving) and promote safety habits (such as use of seatbelts and of helmets), using approaches detailed in this table.** - Address childhood aggression. - Prevent and treat conduct problems. - Instill in adolescents a realistic sense of their ability to drive after drinking. - Enhance the value that adolescents place on safety concerns. *Policy Level* - Delay full licensure among adolescents (graduated driver licensing) and place restrictions on driving at night (curfew laws). - Lower the legal blood alcohol concentration limit for young drivers.
Unintentional Injuries, Risk Behaviors and Safety Habits—Bicycle-related			- Bicycle helmet giveaway programs as stand-alone efforts, not incorporated as one component of a broader bicycle helmet promotion effort.	*Individual Level* - Increase bicycle helmet use, via the approaches detailed in this table. - Implement multi-component bicycle helmet education programs that include components such as education in bicycle safety and in the importance of helmets, distribution of coupons for use toward a helmet purchase, and events designed to raise awareness regarding bicycle helmets. *Family and Peer Level* - Promote bicycle helmet use among parents and peers. *Policy Level* - Implement bicycle helmet laws [extent of enforcement and public awareness of the law may be important].

AREAS FOR TARGETED INTERVENTION ACTIVITIES	WHAT WORKS	WHAT DOESN'T WORK	MIXED REVIEWS	"BEST BETS"
Occupational Injuries				***Individual Level*** **- Reduce on-the-job substance use.** ***Environmental Changes at Work*** **- Reduce exposure to hazards at work, and increase worker training in on-the-job safety.** - Increase supervision at work.

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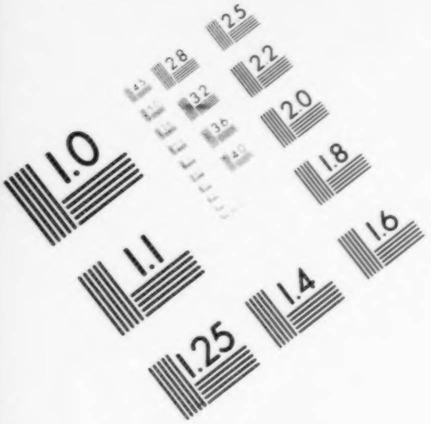
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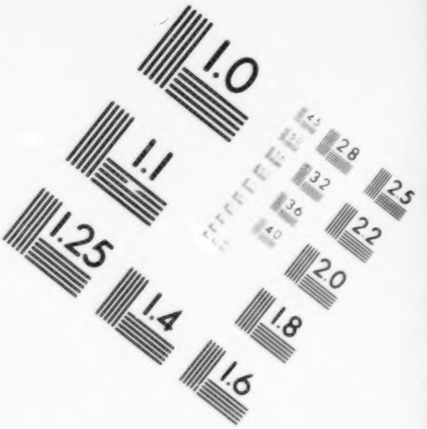
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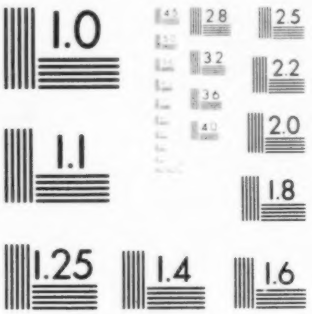
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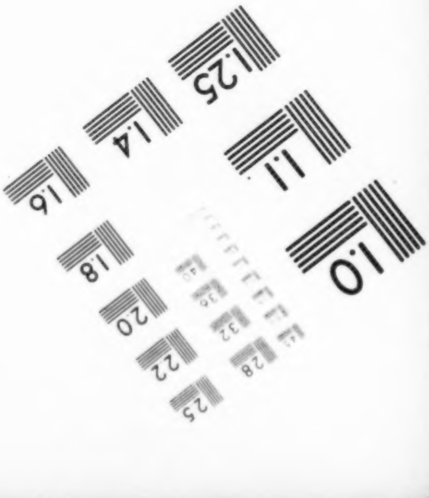
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